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14. ABSTRACT

::multiple abstracts::

We report a new type of holographic interface, which is able to manipulate the three fundamental properties of light (phase, amplitude and polarization) over a broad wavelength range. The design strategy relies on replacing the large openings of conventional holograms by arrays of sub-wavelength apertures, oriented to locally select a particular

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## Report Title

Structured Light in structured media program book

## ABSTRACT

::multiple abstracts::

We report a new type of holographic interface, which is able to manipulate the three fundamental properties of light (phase, amplitude and polarization) over a broad wavelength range. The design strategy relies on replacing the large openings of conventional holograms by arrays of sub-wavelength apertures, oriented to locally select a particular state of polarization. The resulting optical element can therefore be viewed as the superposition of two independent structures with very different length scales, i.e. a hologram with each of its apertures filled with nanoscale openings to transmit only a desired state of polarization. As an implementation we have fabricated a nano-structured holographic plate that can generate radially polarized optical beams from circularly polarized incident light and we have demonstrated that it can operate over a broad range of wavelengths. The ability of a single holographic interface to shape simultaneously amplitude, phase and polarization of light can find widespread applications in photonics.

Benefiting from the flexibility in engineering their optical responses, metamaterials have been used to achieve control over the propagation of light to an unprecedented level, leading to highly unconventional and versatile optical functionalities in comparison to their natural counterparts. Recently the emerging field of meta-surfaces consisting of a monolayer of artificial atoms has offered attractive functionalities of shaping the wave front of light by introducing an interfacial abrupt phase discontinuity. In this talk, I will talk about our recent works on optical metasurfaces consisting of an array of plasmonic rods with spatially varying orientations, where the local phase profile is determined by the orientation of each rod. In particular, I will focus on three examples of device applications: a dual polarity metalens that can functions either a convex or a concave lens, helicity switchable unidirectional excitation of surface plasmon polaritons, and 3D computer generated hologram.

Lens is the most essential part of any imaging systems. Conventional lens are made from dielectric materials, such as glass, with spatially varying topography. The polarity of any lens reported so far cannot be altered after fabrication, i.e., either positive (convex) or negative (concave), depending on the surface topography. We have experimentally demonstrated a counter-intuitive bipolar flat lens with switchable polarity at visible frequencies by controlling the phase discontinuities for the circularly polarized light. The positive and negative polarities are interchangeable in one identical flat lens under inversion of the helicity of the input light. Both focusing and imaging are observed for visible light. We also apply the concept of interfacial phase discontinuity for circularly polarizations on a metasurface to the design of a novel type of helicity dependent SPP unidirectional excitation at normal incidence.

Selective unidirectional excitation of SPPs along opposite directions is experimentally demonstrated at optical frequencies by simply switching the helicity of the incident light. This approach, in conjunction with dynamic polarization modulation techniques, opens gateway towards integrated nanoplasmonic circuits with electrically reconfigurable functionalities. Finally, I will talk about the realization of three dimensional (3D) holography by using metasurfaces. As the phase can be controlled locally at each subwavelength unit cell by the rod orientation, metasurfaces represent a new route towards high-resolution on-axis 3D holograms with wide field of view. In addition, the undesired effects of twin images and multiple diffraction orders usually accompanying holography are eliminated.

The relativistic spin-orbit coupling of electrons results in intrinsic spin precessions and therefore spin-polarization-dependent transverse currents, leading to the observation of spin Hall effect (SHE) and the emerging field of spintronics. The coupling between charge's spin degree of freedom and its orbital movement is essentially identical to the coupling of the transverse electric and magnetic components of a propagating electromagnetic filed. To conserve total angular momentum, an inhomogeneity of material's index of refraction can cause momentum transfer between the orbital and the spin angular momentum of light along its propagation trajectory, resulting in a transverse splitting in polarizations. Such a photonic spin Hall effect (PSHE) was recently proposed theoretically to describe the spin-orbit interaction, the geometric phase, and the precession of polarization in weakly inhomogeneous media as well as the interfaces between homogenous media.

The experimental observation of spin Hall effect of light, however, is fundamentally challenging since the amount of momentum that a photon carries is exceedingly small. The exploration of such a weak process relies on the accumulation of the effect through many multiple reflections or ultra-sensitive quantum weak measurements with pre- and post-selections of spin states. Here we demonstrate experimentally the strong interactions between the spin

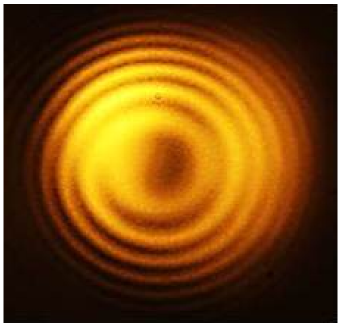
and the orbital momentum of light in a thin metasurface – a two-dimensional electromagnetic nano-structure with designed in-plane phase retardation over the wavelength scale. In such an optically thin material, the resonance-induced anomalous “skew-scattering” of light destroys the axial symmetry of the system and we observed PSHE even at the normal incidence. In stark contrast, for conventional interfaces between two homogeneous media, the spin-orbit coupling does not exist at the normal incidence.

The arbitrary control of electromagnetic (EM) waves is a key aim of photonic research. Conventional optical materials have limited abilities to manipulate EM waves due to their limited variation ranges of material parameters. Metamaterials (MTM), artificial composites made by EM microstructures in deep-subwavelength scales, can possess arbitrary values of permittivity $\varepsilon$ and permeability $\mu$ and thus offer much expanded freedoms to manipulate EM waves. In this talk, I will briefly review our recent efforts, both theoretically and experimentally, in employing MTMs (especially ultra-thin inhomogeneous MTMs, i.e., meta-surfaces) to control EM waves in various aspects. Examples include how to make high-conducting transparent metals and how to bridge propagating EM waves and surface EM waves by gradient mea-surfaces.

*additional abstracts are in attached program book

**Conference Name:** Structured Light in structured media

**Conference Date:** September 29, 2013



**Structured Light in Structured Media**
**From Classical to Quantum Optics Incubator**

**29 September – 1 October 2013**
**OSA Headquarters ● Washington, DC, USA**

HOSTED BY:
**Richard Hammond**, *Army Research Office, USA*
**Natalia Litchinitser**, *State University of New York at Buffalo, USA*

# AGENDA

## 29 September 2013

### Welcome Dinner

18:00 Welcome Dinner
Ezmè, 2016 P Street, NW, Washington, DC

## 30 September 2013

### Breakfast

7:30 OSA Headquarters
2010 Massachusetts Avenue, NW

### Opening Remarks

7:50 Elizabeth A. Rogan, Chief Executive Officer, OSA, United States
Richard Hammond, Army Research Office, United States

### Metasurfaces

8:05-8:30 Holographic Metasurfaces
Patrice Genevet, Harvard University, United States

8:30-8:55 Manipulating Light with Plasmonic Metasurfaces with Orientation Controlled Phase Profile
Shuang Zhang, University of Birmingham, United Kingdom

8:55-9:20 Optic Spin Hall Effect at Metasurfaces
Xiaobo Yin, University of California, Berkeley, United States

9:20-9:45 Metasurfaces to Control Electromagnetic Waves
Lei Zhou, Fudan University, China

**9:45-10:00 Coffee Break**

## Empowering Optical Communications

10:00-10:25 Optical Communications using OAM-based Multiplexing
Alan Willner, University of Southern California, United States

10:25-10:50 On Fiber Modes and Space-Division Multiplexing in Fiber-Optic Communication Systems, Rene Essiambre, Alcatel-Lucent, United States

10:50-11:15 Light That Twists Inside Fibers
Siddharth Ramachandran, Boston University, United States

11:15-11:40 Metaoptics Transforms Laser Filamentation Studies
Martin Richardson, University of Central Florida, United States

11:40-12:05 Twisting Light with Metamaterials
Natalia Litchinitser, University of Buffalo, United States

**12:05-13:00 Lunch Break [Provided]**

## From Classical to Quantum

13:00-13:25 Metamaterials for Quantum Optics
Vlad Shalaev, Purdue University, United States

13:25-13:50 Quantum Temporal Imaging: The Need for Advanced Dispersion Engineering
Daniel Gauthier, Duke University, United States

13:50-14:15 Quantum Aspects of Transverse Degrees of Freedom of Photons: Generation, Detection and Applications
Robert Boyd, University of Ottawa, Canada

14:15-14:40 Structured Metatronics for Photonic Functionality
Nader Engheta, University of Pennsylvania, United States

14:40-15:05 Quantum Conductivity Theory for Nanoplasmonic Systems
Joe Haus, University of Dayton, United States

**15:05-15:20 Coffee Break**

## Structured Light and Matter

15:20-15:45 Electromagnetically Induced Transparency of Structured Light
Sonja Franke-Arnold, University of Glasgow, United Kingdom

15:45-16:10 Frenkel Exciton Sources for the Generation of Structured Light by Molecular Arrays
David Andrews, University of East Anglia Norwich, United Kingdom

16:10-16:35 Structured Light in Photonic Graphene
Anton Desyatnikov, Australian National University, Australia

16:45-17:10 Optical Vortex Generation at Small Scale
Etienne Brasselet, Université de Bordeaux, France

17:10-17:35 Designing Meta-atoms for Transformation Optics
Gabriel Molina-Terriza, Macquarie University, Australia

17:35-18:00 Tunable Coherent Multicolored Vector Vortex Beam Generator using a q-plate
Yisa Rumala, Institute for Ultrafast Spectroscopy and Lasers, City College-CUNY, United States

18:00-18:25 Broadband Absorption Engineering of Patterned Hyperbolic Metafilms
Qiaoqiang Gan, University of Buffalo, United States

19:00 Dinner
Sette Osteria, 1666 Connecticut Ave, NW, Washington, DC

***The following people will have posters on display throughout the day:***

- *Andrei Afanasev, George Washington University*
- *Guarav Jayaswal, University of Padova*
- *Eric Johnson, Clemson University*
- *Zhaxylyk Kudyshev, University of Buffalo, The State University of New York*
- *Yongmin Liu, Northeastern University*
- *Tania Moein, University of Buffalo, The State University of New York*

## 1 October 2013

## Breakfast

7:30 am OSA Headquarters
2010 Massachusetts Avenue, NW

## Fundamentals of Structured Light and Matter

8:00-8:25 Engineered Density of Photonic States: What Can it Do?
Mikhail Noginov, Norfolk State University, United States

8:25-8:50 Inverse Methods and Managing Electromagnetic Waves using Metamaterials
Michael Fiddy, University North Carolina, United States

8:50-9:15 Structured Darkness
Grover Swartzlander, Rochester Institute of Technology, United States

9:15-9:40 Extraordinary Momentum and Spin in Evanescent Waves
Konstantin Bliokh, Institute of Radio Astronomy, Ukraine

9:40-10:05 Optical Nonlocalities and Additional Waves in Uniaxial Metamaterials
Viktor Podolskiy, University of Massachusetts, Lowell, United States

**10:05 -10:20 Coffee Break**

## Structured Light in Action

10:20-10:45 Using Random Optical Patterns to Recover Full Resolution 3D Images
Miles Padgett, University of Glasgow, United Kingdom

10:45-11:10 Structured Light Beams for Nano and Microscale Manipulation
Halina Rubinsztein-Dunlop, University of Queensland, Australia

11:10-11:35 Laser Processing with Ultra-Short Vortex Pulses
Wieslaw Krolikowski, Australian National University, Australia

11:35-12:00 Angular Momentum of Light Forces Materials to Become Chiral Nano-Structures
Takashige Omatsu, Chiba University, Japan

12:00-12:25 Harnessing Light for Sensing and Guiding at Mesoscales
Aristide Dogariu, University of Central Florida, United States

**12:25-13:25 Lunch [Provided]**

## Linear and Nonlinear Nanostructures

13:25-13:50 Electrically Controlled Nonlinear Phenomena in Optical Metamaterials
Wenshan Cai, Georgia Institute of Technology, United States

13:50-14:15 Harmonic Resonance Cones in Hyperbolic Metamaterials
Domenico de Ceglia, National Research Council, United States

14:15-14:40 Nonlinear Optical Interactions in Plasma Resonant Materials
Maria Antonetta Vincenti, National Research Council, United States

14:40-15:05 Backward Waves in Metamaterials
Ildar Gabitov, University of Arizona, United States

15:05-15:30 Towards Fabrication of Right-Sized Nanostructured Metamaterials
Alexander Cartwright, University at Buffalo, SUNY, United States

15:30-15:55 Plasmon Drag Effect in Metal Films and Nanostructures
Natalia Noginova, Norfolk State University, United States

## Closing Remarks

15:55-16:00 Rich Hammond, United States Army Research Laboratory, United States

***The following people will have posters on display throughout the day.***

- *Garreth Ruane, Rochester Institute of Technology*
- *Mikhail Shalaev, University at Buffalo, The State University of New York*
- *Jingbo Sun, University at Buffalo, The State University of New York*
- *Xi Wang, University of Buffalo, The State University of New York*
- *Jinwei Zeng, University at Buffalo, The State University of New York*

## 30 September 2013

## Metasurfaces

### *8:05-8:30* ***Holographic Metasurfaces,*** *Patrice Genevet, Harvard University*

We report a new type of holographic interface, which is able to manipulate the three fundamental properties of light (phase, amplitude and polarization) over a broad wavelength range. The design strategy relies on replacing the large openings of conventional holograms by arrays of sub-wavelength apertures, oriented to locally select a particular state of polarization. The resulting optical element can therefore be viewed as the superposition of two independent structures with very different length scales, i.e. a hologram with each of its apertures filled with nanoscale openings to transmit only a desired state of polarization. As an implementation we have fabricated a nano-structured holographic plate that can generate radially polarized optical beams from circularly polarized incident light and we have demonstrated that it can operate over a broad range of wavelengths. The ability of a single holographic interface to shape simultaneously amplitude, phase and polarization of light can find widespread applications in photonics.

### *8:30-8:55* ***Manipulating Light with Plasmonic Metasurfaces with Orientation Controlled Phase Profile,*** *Shuang Zhang, University of Birmingham*

Benefiting from the flexibility in engineering their optical responses, metamaterials have been used to achieve control over the propagation of light to an unprecedented level, leading to highly unconventional and versatile optical functionalities in comparison to their natural counterparts. Recently the emerging field of meta-surfaces consisting of a monolayer of artificial atoms has offered attractive functionalities of shaping the wave front of light by introducing an interfacial abrupt phase discontinuity. In this talk, I will talk about our recent works on optical metasurfaces consisting of an array of plasmonic rods with spatially varying orientations, where the local phase profile is determined by the orientation of each rod. In particular, I will focus on three examples of device applications: a dual polarity metalens that can functions either a convex or a concave lens, helicity switchable unidirectional excitation of surface plasmon polaritons, and 3D computer generated hologram.

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### *8:55-9:20* ***Optic Spin Hall Effect at Metasurfaces,*** *Xiaobo Yin, University of California, Berkeley*

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The experimental observation of spin Hall effect of light, however, is fundamentally challenging since the amount of momentum that a photon carries is exceedingly small. The exploration of such a weak process relies on the accumulation of the effect through many multiple reflections or ultra-sensitive quantum weak measurements with pre- and post-selections of spin states. Here we demonstrate experimentally the strong interactions between the spin and the orbital momentum of light in a thin metasurface – a two-dimensional electromagnetic nano-structure with designed in-plane phase retardation over the wavelength scale. In such an optically thin material, the resonance-induced anomalous "skew-scattering" of light destroys the axial symmetry of the system and we observed PSHE even at the normal incidence. In stark contrast, for conventional interfaces between two homogeneous media, the spin-orbit coupling does not exist at the normal incidence.

### *9:20 – 9:45* ***Metasurfaces to Control Electromagnetic Waves,*** *Lei Zhou, Fudan University*

The arbitrary control of electromagnetic (EM) waves is a key aim of photonic research. Conventional optical materials have limited abilities to manipulate EM waves due to their limited variation ranges of material parameters. Metamaterials (MTM), artificial composites made by EM microstructures in deep-subwavelength scales, can possess arbitrary values of permittivity ε and permeability μ and thus offer much expanded freedoms to manipulate EM waves. In this talk, I will briefly review our recent efforts, both theoretically and experimentally, in employing MTMs (especially ultra-thin inhomogeneous MTMs, i.e., meta-surfaces) to control EM waves in various aspects. Examples include how to make high-conducting transparent metals and how to bridge propagating EM waves and surface EM waves by gradient mea-surfaces.

**9:45-10:00 Coffee Break**

## Empowering Optical Communications

### ***10:00-10:25 Optical Communications using OAM-based Multiplexing,*** *Alan Willner, University of Southern California*

The optical communications community is continually interested in advances that can achieve higher system data capacity and spectral efficiency. The field has historically experienced significant capacity growth by multiplexing many channels within one domain, as well as combining multiple orthogonal domains. For example, wavelength-division-multiplexing (WDM) of multiple wavelength channels combined with polarization multiplexing (pol-mux) of channels on two orthogonal polarizations has been accepted as a leading approach. Since the C-band optical spectrum is being exhausted and there exist only 2 orthogonal polarizations, the community is aggressively researching the multiplexing of multiple spatially overlapping orthogonal modes (i.e. mode-division-multiplexing, MDM) as a possible next domain to exploit.

One MDM approach is multiplexing of optical beams carrying orbital angular momentum (OAM). Each optical OAM beam possesses a unique “twisting” of its phase front, such that multiple beams each carrying a different amount of phase twist are orthogonal to each other. OAM multiplexing not only increases transmission capacity, but the system spectral efficiency can also be dramatically increased if many orthogonal beams are transmitted using the same wavelength. It should be emphasized that OAM-based mode multiplexing is orthogonal to and can be combined with other multiplexing techniques, such as WDM and pol-muxing.

In this presentation, we will discuss recent advances in data transmission using OAM that include: (a) transmission of single wavelength pol-mux data channels over OAM beams with a transmission capacity of 2.5 Tbit/s and a spectral efficiency of ~95 bit/s/Hz; (b) a transmission capacity of 100 Tbit/s utilizing multi-dimensional multiplexing of 24 OAM modes on each of 42 wavelengths for a total of 1008 orthogonal data channels; and (c) reconfigurable optical networking functions for OAM-based systems with emphasis on reconfigurable channel add/drop multiplexing of OAM modes, dynamic data exchange among different OAM modes, and multicasting of data onto multiple output OAM modes.

### ***10:25-10:50 On Fiber Modes and Space-Division Multiplexing in Fiber-Optic Communication Systems,*** *Rene Essiambre, Alcatel-Lucent*

Transmission of information on fiber links longer than a few hundred meters is performed nearly exclusively over single-mode fibers (SMFs) in current optical networks. The capacity of SMFs has steadily increased in three decades, with the latest laboratory demonstrations achieving a record capacity of 100 Tb/s. This capacity growth has helped provide high speed internet access at relatively low cost. However, today we are only a few years away from closely approaching the capacity limit of standard SMFs, due to Kerr nonlinearity. This nonlinear capacity limit is estimated to be 170 Tb/s for a 500-km system using 80 nm of bandwidth.

In recent years, it has become clear that fibers supporting multiple spatial modes have the potential to greatly increase the capacity per fiber strand by using space-division multiplexing (SDM). In fact, laboratory demonstrations have recently exceeded the capacity limit of standard SMFs by using multimode and multicore fibers. Even though it is still unclear if there is an “optimum” SDM fiber that maximizes the capacity of SDM systems, there are tremendous opportunities for considering structured light in fibers as a means to potentially reduce system complexity and increase fiber capacity. In this talk, I will start by introducing the nonlinear capacity limit of SMFs, then cover the recent capacity results of SDM transmission using multimode and multicore fibers, and finally discuss future perspectives for SDM transmission systems.

### *10:50-11:15* ***Light That Twists Inside Fibers,*** *Siddharth Ramachandran, Boston University*

Transmission of information on fiber links longer than a few hundred meters is performed nearly exclusively over single-mode fibers (SMFs) in current optical networks. The capacity of SMFs has steadily increased in three decades, with the latest laboratory demonstrations achieving a record capacity of 100 Tb/s. This capacity growth has helped provide high speed internet access at relatively low cost. However, today we are only a few years away from closely approaching the capacity limit of standard SMFs, due to Kerr nonlinearity. This nonlinear capacity limit is estimated to be 170 Tb/s for a 500-km system using 80 nm of bandwidth.

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### *11:15-11:40* ***Metaoptics Transforms Laser Filamentation Studies,*** *Martin Richardson, University of Central Florida*

Filamentation of laser beams is a phenomenon that can occur in any media. Invariably it results from a combination of non-linear phenomena that combine to radically affect the character and divergence of propagating beams. Initiated by a laser-induced change in the refractive index, the most commonly optical Kerr effect. In its most ideal form, most clearly evident in gases, including atmospheric air, a pulsed laser beam with a Gaussian spatial profile is transformed into a self-sustaining filament comprising a high-intensity central region surrounded by a lower intensity carrier field or photon bath that can propagate for 100’s meters without significant change in spatial scale.  In air and other gases with femtosecond laser pulses its onset occurs at a certain critical power (a few GW for 800 nm pulses). When lasers with much higher powers are used, then these same nonlinear processes lead to noise-induced breakup of the laser beam into random distributions of independent filaments propagating with little or no spatial interrelationship. Many near-term potential applications in atmospheric sensing, long-

distance ablation and possibly energy guiding would benefit from the ability to transform these random distributions of filaments into engineered arrays of filaments having fixed deterministic spatial orientations. In recent years several approaches have been pursued to achieve this goal. In this talk we will review these approaches. They include the generation of filaments with Airy and Bessel beams and other beam configurations. We will also describe the advances our partnership has made in the use of metaoptical phase-changing elements in creating complex arrays of filaments. Finally we will speculate on some potential applications of these advanced arrays of filaments might enable.

***11:40-12:05 Twisting Light with Metamaterials,*** *Natalia Litchinitser, University of Buffalo*

We investigate novel optical phenomena at the interface of two emerging fields of modern optical physics - singular optics and optical metamaterials. In particular, we discuss our recent theoretical, numerical, and experimental studies of structured light interactions with optical metamaterials made on optical fiber platform. These studies resulted in the following main findings: i) Magnetic metamaterials can be used to manipulate complex polarization states; ii) Negative index metamaterials could be used to engineer phase front, wavelength and the OAM of singular beams; iii) Backward phase-matched process in NIMs with quadratic nonlinearity results in generation of backward propagating vortex beam with doubled frequency and orbital angular momentum and reversed rotation direction of the wavefront; iv) Strongly anisotropic indefinite optical metamaterials structures can be designed to enable transformations of orbital angular momentum. Finally, we outline future directions of these studies.

**12:05-13:00 Lunch Break [Provided]**

## From Classical to Quantum

***13:00-13:25 Metamaterials for Quantum Optics,*** *Vlad Shalaev, Purdue University*

Metamaterials enable a new, unorthodox approach of enhancing the nanoscale light-matter interaction in a broad bandwidth by provide the quantum emitter with a plethora of electromagnetic states. Current nanofabrication technologies allow the engineering of the dielectric constant with metamaterials, transforming the space perceived by light to be metallic in one direction and dielectric in another. This lifts the restriction on the well-known closed spherical dispersion relation of an isotropic medium into a hyperboloid, leading to electromagnetic states unique to the metamaterial. An infinite number of metamaterial states can lie on this hyperboloid (in the low-loss, effective-medium limit), increasing the interaction with the quantum emitter while simultaneously channeling the light into a subdiffraction single-photon resonance cone.

We experimentally demonstrate a broadband enhancement of emission from nitrogen-vacancy (NV) centers in nanodiamonds. The enhancement is achieved by using a multilayer metamaterial with hyperbolic dispersion. The metamaterial is fabricated as a stack of alternating gold and alumina layers. Our approach paves the way towards the construction of efficient single-photon sources as planar on-chip devices.

In comparison to other proposed techniques for single-photon emission enhancement, this method is based on a non-resonant way of engineering the electromagnetic environment which provides enhancement across the entire emission range of NV centers. In the future, we would like to achieve higher enhancement by building HMMs based on different designs and low-loss constituent materials. Such a diamond – metamaterial device can serve as a proof of principle for more complex structures that can bring quantum optical technologies to life.

***13:25-13:50 Quantum Temporal Imaging: The Need for Advanced Dispersion Engineering,*** *Daniel Gauthier, Duke University*

Temporal imaging systems are analogous to traditional spatial imaging systems in that they can magnify, minify, and invert a temporal segment of an optical waveform. In the quantum domain, temporal imaging is important for increasing the efficiency of light-matter interfaces and is crucial for creating hybrid quantum memories consisting of disparate qubits. I will review our progress on developing a quantum temporal imaging system and highlight the urgent need to develop compact photonic devices that have large group velocity dispersion. I will also discuss our recent discovery of giant all-optical tunable group velocity dispersion in a laser-pumped photonic crystal fiber. Finally, I will speculate on other approaches for realizing engineered dispersion in nanophotonic devices.

***13:50-14:15 Quantum Aspects of Transverse Degrees of Freedom of Photons: Generation, Detection and Applications,*** *Robert Boyd, University of Ottawa*

Optical fields as a consequence of Maxwell equations, neglecting a small longitudinal component along propagation direction in the paraxial regime, are fairly transverse. Beside wavenumber and polarization, there are at least two independent indices that define the transverse structure of an optical field associated with the transversality of the optical field. These transverse degrees of freedom are associated with phase structures of the azimuthal and radial modes of a photon in the cylindrical coordinates. In my talk, I will discuss the quantum nature of these degrees of freedom in both cartesian and cylindrical coordinates and their possible applications in quantum communication.

***14:15-14:40 Structured Metatronics for Photonic Functionality,*** *Nader Engheta, University of Pennsylvania*

We have been exploring the structural orders of optical metatronic circuitry and metamaterials for new functionalities and optical manipulations. We are interested in how subwavelength optical nanostructures and structured media can form “functioning systems” that may provide us with interesting wave-based platforms for various optical functionalities such as optical data filtering, manipulation and processing, nonreciprocal elements, and system tunability. These may involve structures that behave as digital “meta-bits” and “meta-bytes” acting as building blocks for digital optical metatronics and binary metamaterials. With proper combinations of such meta-bits, we can achieve exciting photonic functionalities. These topics will be discussed in this presentation.

***14:40-15:05*** ***Quantum Conductivity Theory for Nanoplasmonic Systems,*** *Joe Haus, University of Dayton*

We apply quantum mechanics to calculate the tunneling current between two nanoplasmonic contacts with an insulator sandwiched between them. Using the photon assisted tunneling current we derive a set of quantum conductivity coefficients which correspond to a linear ac conductivity and additional nonlinear coefficients that modulate the field amplitude at the fundamental frequency and its harmonics. The quantum conductivities, determined with no fit parameters, have both frequency and gap dependence that can be applied to determine the nonlinear quantum effects of strong applied electromagnetic fields even in dissimilar metal nanostructures.

**15:05-15:20 Coffee Break**

## Structured Light and Matter

***15:20-15:45*** ***Electromagnetically Induced Transparency of Structured Light,*** *Sonja Franke-Arnold, University of Glasgow*

How does holographically shaped light interact with cold atoms? Scattering of light by atoms, and its absorption, is usually sensitive only to the intensity profile of a light beam. By simultaneously driving multiple atomic transitions, it is possible to modify the absorption profile of a "signal" laser due to the presence of a second "control" beam, an effect known as EIT.

We report first our observations of EIT with holographically shaped light beams, namely light carrying orbital angular momentum. The shaped signal and control light modify the atomic populations, generating spatially varying atomic dark states. This generates a spatially varying transparency of the atoms, with a profile encoded onto the transmitted light. The whole process therefore converts optical phase information into intensity information.

***15:45-16:10*** ***Frenkel Exciton Sources for the Generation of Structured Light by Molecular Arrays,*** *David Andrews, University of East Anglia Norwich*

Optical vortex light is commonly produced by the imposition of a distributed phase on the structure of a conventional laser beam. Recent theoretical studies indicate that it is possible to engineer direct sources for the generation of structured light by nanofabricated molecular materials. Such methods aim to exploit the excitation of Frenkel excitons in molecular arrays of designed geometry and symmetry. Achieving an azimuthal phase progression around the components of each array will allow for each individual nanoarray to support delocalized excitons, whose electronic decay generates light with a helical wave-front; increasing the number of components provides for the achievement of a higher degree of twist. Practical considerations are discussed, and potential new applications are also identified.

***16:10-16:35*** ***Structured Light in Photonic Graphene,*** *Anton Desyatnikov, Australian National University*

Graphene-like honeycomb lattices have been a subject of extensive research in various fields over past decade, from condensed matter physics and ultracold atoms to electromagnetic waves. The main reason for honeycomb lattices being so intriguing is the presence of diabolical points in the momentum space and the fact that wave excitations in the neighbourhood of these singular points can be described by the massless Dirac equation. As a result, a uniformly polarized (scalar) optical wave propagating in a honeycomb lattice of weakly coupled waveguides, called photonic graphene, carries pseudo-spin degree of freedom associated with the two triangular sublattices comprising honeycomb lattice. We study the relation of pseudo-spin with optical angular momentum (AM) and corresponding peculiar spatial structure of a laser beam. Specifically, we study AM dynamics by simulating the evolution of a scalar wave packet confined to the Dirac cone, i.e. conical diffraction, using Schrödinger equation. On one hand, we confirm the prediction of the Dirac model that the sum of the pseudo-spin AM and the orbital angular momentum (OAM) of the envelope slowly varying on a scale of the lattice period is a constant of motion. However, the OAM is not conserved, and quite surprisingly, it follows qualitatively the pseudo-spin dynamics instead of the total AM in the Dirac model. This result is dramatically modified in staggered honeycomb lattices with two unequal sub-lattices corresponding to parity symmetry breaking potential: the OAM does not follow the pseudo-spin anymore and it is very sensitive the lattice asymmetry. Our findings pose several questions on possible relations between pseudo-spin and true physical AM as well as suggest an analogy with spin-like orbital angular momentum of a structured optical beam.

***16:45-17:10*** ***Optical Vortex Generation at Small Scale,*** *Etienne Brasselet, Université de Bordeaux*

The generation of optical vortices is a basic example of structuration of light. This often implies the use of structured media that enable to shape the topological feature of a light beam. The realization of singular optical elements allowing on-demand generation of optical vortices at small scale therefore represents a modern challenge in optics towards the development of singular integrated optics. Here will be presented recent advances on this topic that have been achieved at University of Bordeaux. This includes the use of various kinds of materials that can be either organic (amorphous glasses, liquid crystals), inorganic (metals), or hybrid (photopolymerizable media). In all cases, the controlled generation of optical vortices is done via a topologically structured light-matter interaction, with an emphasis on the spin-orbit interaction of light.

***17:10-17:35*** ***Designing Meta-Atoms for Transformation Optics,*** *Gabriel Molina-Terriza, Macquarie University*

The objective in the field of transformation optics is to design metamaterials which are capable of inducing transformations in the electromagnetic field which are equivalent to the ones produced by the metric of gravitational objects. Strategies are then needed to optimally design both the meta-atoms in the metamaterials and their arrangement. We need then to understand the electromagnetic properties of these nanostructures and how they relate to the physics of electromagnetic fields propagating in general space-time metrics. We have recently found that the experimental results on the interaction of light and matter at the nanoscale can be predicted and explained using the transformations produced by

the helicity and the angular momentum operators. In this talk I will explain how these results can help us in designing metamaterials which can be useful in transformation optics.

***17:35-18:00 Tunable Coherent Multicolored Vector Vortex Beam Generator using a q-plate,***
*Yisa Rumala, Institute for Ultrafast Spectroscopy and Lasers, City College-CUNY*

Spatially coherent multicolored vector vortex beams is created using a tunable q-plate and supercontinuum light source. The polarization topology of the beam is mapped, and the feasibility of the experimental setup as an optical spectral filter is demonstrated. A Hybrid mode-wavelength division multiplexing (HMWDM) scheme is proposed, were information is encoded in the wavelength of light, and the spatial mode and polarization modulation about the optical mode is used to turn on and off different frequency channels. Potential applications include ultradense device multiplexing and data networking (e.g. between computers).

***18:00-18:25 Broadband Absorption Engineering of Patterned Hyperbolic Metafilms,***
*Qiaoqiang Gan, University of Buffalo*

Perfect absorbers are important optical components required by a variety of applications. For instance, efficient optical absorbers are highly desired on the microscale where they can play a significant role in preventing crosstalk between optical interconnects on integrated photonic chips. In the thermal spectral region, waste heat is a major energy loss (including thermal radiation loss) in both industrial sectors and our daily life. While there is great interest in achieving highly absorptive materials exhibiting large broadband absorption using optically thick, micro-structured materials, it is still challenging to realize ultra-compact subwavelength absorber for on-chip optical/thermal energy applications. In recent years, intensive research efforts have been performed to realize compact/portable metamaterial resonant perfect absorbers. However, these resonant absorbers can usually be realized within relatively narrow bands at microwave, terahertz and infrared - visible frequencies for given incident angle and polarization state, due to the inherently narrow-band plasmon resonances. To overcome these limitations, in this presentation, we will discuss a patterned hyperbolic meta-film with engineered and freely tunable absorption band from near-IR to mid-IR spectral regions based on multilayered metal/dielectric films. Compared with recently reported compact plasmonic/meta-absorber based on crossed trapezoid grating arrays and ultra-sharp convex metal grooves, the proposed hyperbolic metafilm pattern is superior on its ultra-wide spectral tunability from optical (i.e. visible to near-IR) to thermal (i.e. mid- and far-IR) spectral regions, and can be easily integrated with other on-chip electronic/optoelectronic devices, which is promising to create new regimes of optical/thermal physics and applications.

***The following people will have posters on display throughout the day:***

- *Andrei Afanasev, George Washington University*
- *Guarav Jayaswal, University of Padova*
- *Eric Johnson, Clemson University*
- *Zhaxylyk Kudyshev, University of Buffalo, The State University of New York*
- *Yongmin Liu, Northeastern University*
- *Tania Moein, University of Buffalo, The State University of New York*

## 1 October 2013

## Fundamentals of Structured Light and Matter

***8:00-8:25 Engineered Density of Photonic States: What Can it Do?*** *Mikhail Noginov, Norfolk State University*

Optical cavities, plasmonic structures, photonic band crystals, interfaces, as well as, generally speaking, any photonic media with spatially inhomogeneous dielectric permittivity (including metamaterials) have local densities of photonic states, which are different from that in vacuum. All these modified density of states environments are known to control both rate and angular distribution of spontaneous emission. We ask the question whether proximity to metallic and metamaterial surfaces can affect other physical phenomena of fundamental and practical importance.

We show that the same substrates and the same density of state distributions, which boost spontaneous emission, inhibit Förster energy transfer between donor and acceptor molecules doped into a thin polymeric film. This finding correlates with the fact that in dielectric media, in which the density of photonic states is related to the index of refraction $n$, the rate of spontaneous emission is proportional to $n$ while the rate of the donor-acceptor energy transfer (in solid solutions with random distribution of acceptors) is proportional to $n^{-1.5}$. This heuristic correspondence suggests that other classical and quantum phenomena, which in regular dielectric media depend on $n$, can too be controlled with custom-tailored metamaterials, plasmonic structures, and cavities.

***8:25-8:50 Inverse Methods and Managing Electromagnetic Waves using Metamaterials,*** *Michael Fiddy, University North Carolina*

Manipulating light for object illumination or imaging has typically relied on weak interaction models (Born and Rytov approximations) or material properties understood in terms of effective media approximations. For example, one can generate subwavelength sized spots with single scattering bandlimited masks and exploit superoscillations [1]. Over the last ten years, new materials exploiting sub-wavelength sized resonant meta-atoms have been designed, fabricated and assembled into bulk metamaterials with unique dispersive scattering properties. The arrangement of meta-atoms on a subwavelength scale and the coupling between them defines bulk scattering properties that can manage light but each meta-atom, being a small antenna, will have a $Q \sim 1/(ka)^3$,[2]. Increasing Q by decreasing the size “a” of a meta-atom comes with improved homogenization and possibly lower losses near resonance, but slower response times. A so-called perfect lens, homogenized to n = -1, might take a millennium to achieve ved/50 resolution [3] and is images of 3D scattering objects. Also, small inhomogeneities in material properties along with fabrication tolerances, conspire to diminish high Q phenomena resulting in averaged and less interesting properties, as dictated by the random phase approximation (RPA). In this presentation we consider the design and fabrication of small clusters of meta-atoms, which retain their resonance-driven properties, but which remain inhomogenous scattering structures. There are strong analogies with the electrodynamics of atoms and small molecules and the exploitation of multipolar transitions. As structured scattering elements, different configurations of meta-atoms can represent different material phases in their response. We show how these metamaterials can i) transfer evanescent waves into propagating waves making them useful for superresolution via computational (coded) inverse

scattering-based imaging and ii) also exhibit nonlinear responses such as frequency generation. We also speculate on the application of inverse methods developed for strongly scattering media, for their design.

***8:50-9:15*** **_Structured Darkness,_** *Grover Swartzlander, Rochester Institute of Technology*

Abstract: Optical vortices are characterized by a core region wherein destructive interference occurs, rendering the region dark. Within the core is a nodal point associated with total destructive interference. Vortex cores come in two varieties – those with vanishing small cores, and those with characteristically large cores. The physics distinguishing these two states is as profound as the difference between a tropical storm and a category five hurricane. Recently we have discovered a third type of vortex beam that possesses not a nodal point, but rather a nodal area. Such beams are important corollaries in the science of structured light.

***9:15-9:40*** **_Extraordinary Momentum and Spin in Evanescent Waves,_** *Konstantin Bliokh, Institute of Radio Astronomy*

Momentum and spin represent fundamental dynamical properties of quantum particles. For photons, momentum is associated with the wave vector and is independent of polarization. In turn, spin is associated with a circular polarization and is also collinear with the wave vector. We show that situation becomes strikingly different for evanescent optical waves. First, evanescent waves possess momentum component, which depends on circular polarization and is orthogonal to the wave vector. Second, there is a spin angular momentum, which is largely independent of the polarization, and is also orthogonal to the wave vector. Although these extraordinaryproperties seem to be in contradiction with what we know about photons, we show that they reveal a fundamental quantum spin current hidden in propagating fields. Numerical calculations of the Mie scattering demonstrate that the transverse momentum and spin push and twist an absorbing probe particle in an evanescent field, so that they can be detected straightforwardly.

***9:40-10:05*** **_Optical Nonlocalities and Additional Waves in Uniaxial Metamaterials,_** *Viktor Podolskiy, University of Massachusetts, Lowell*

Uniaxial anisotropic materials have recently found numerous applications in negative refraction, microscopy, sensing, and optical processing. Anisotropic composites have been proposed to enable a number of other applications, ranging from subwavelength confinement and tunneling of optical radiation to invisibility cloaks. Nanowire-based metamaterials have been proven to provide a versatile platform that combines relatively low absorption with flexibility to realize uniaxial systems with elliptic, epsilon-near-zero (ENZ), with strongly anisotropic (hyperbolic) optical landscape. However, it has been demonstrated that the properties of nanowire composites deviate from the predictions of effective medium theories in the most sought-for ENZ and hyperbolic regimes. Although has been suggested that these deviations are related to optical nonlocality, the dependence of effective permittivity of metamaterials on wavevector of optical waves, the details of this unusual response were not completely understood.

In this work we present an analytical description of nonlocal electromagnetism in uniaxial composites. We show that additional electromagnetic waves, previously discovered in nanowire systems in epsilon-near-zero regime, originate from collective propagating plasmon polariton supported by the structure, and derive the dispersion of this wave. We map the light propagation in plasmonic arrays to coupled-oscillator problem with two oscillators describing the dynamics of the propagating plasmon polariton, and the behavior of its localized plasmon counterpart.

We show that additional electromagnetic waves represent an extra information channel that can only be accounted for by nonlocal effective medium description. Finally, we discuss the effect of this information channel on optical properties of the composite and, in particular, on boundary conditions describing coupling between the metamaterials and the free-space.

**10:05 -10:20 Coffee Break**

## Structured Light in Action

***10:20-10:45 Using Random Optical Patterns to Recover Full Resolution 3D Images,*** *Miles Padgett, University of Glasgow*

Computational ghost imaging (GI) is an alternative technique to conventional imaging and removes the need for a spatially resolving detector. Instead, ghost imaging infers the scene by correlating the known spatial information of a changing incident light field with the reflected intensity.

In classical GI a copy of the light field is usually made with a beam splitter, one copy of the light field interacts with the object and a non spatially resolving detector and the other copy is recorded with a camera. Correlations between the two detectors yield an image. These classical GI systems can be simplified further by introducing a device capable of generating computer programmable light fields, which negates the requirement for the beam splitter and the camera – since knowledge of the light field is held in the computer memory, this type of system is termed computational GI.

Computational Ghost Imaging system can be extended by the addition of further photodiodes to give 3D profiles of the object. We employ shape from shade to give the surface gradient of the object from which the 3D profile can be deduced. This approach is of particular relevance for imaging outwith the visible spectrum where the availability of cameras that might form part of a stereoscopic imaging system is limited.

***10:45-11:10 Structured Light Beams for Nano and Microscale Manipulation,*** *Halina Rubinsztein-Dunlop, University of Queensland*

Structured light fields under high-numerical aperture optics can be used to organise atoms, particles into arrays and functional solids. These light fields are often constructed out of beam modes in the paraxial regime. Paraxial beam modes have a simple representation and can readily be transformed between different bases. Once paraxial modes enter a high-numerical aperture system vector effects absent from the paraxial formulation begin to play a part and the relevant physics changes. Using the

known relationships between the Laguerre– Gauss, Hermite– Gauss, and Ince– Gauss modes we relate the three bases to the vector spherical harmonic symmetries. We investigate how the resulting full wave modes differ under a high-numerical aperture system including how well the resulting fields obey the Gouy phase shift. We calculate the optical forces in such beams. Possible applications include atomic clouds in rings of light with high orbital angular momentum, particle sorting and structural formation of functional solids. We investigate both beam-like (self-Fourier, so shape-preserving) modes and non-beam-like (not self-Fourier) modes.

### *11:10-11:35* **Laser Processing with Ultra-Short Vortex Pulses,** *Wieslaw Krolikowski, Australian National University*

Studies on the interaction of ultra-short laser pulses with solids have led to the discovery of two major phenomena. It has been shown that the interaction of a single pulse with matter is essentially an intensity-dependent process and the ensuing material modification bears almost no signature on the light polarization. On the other hand, the response of many materials to multiple pulse irradiation depends on both the intensity and polarization of the light field and leads to structured, polarization-dependent changes in the material. Vector beams, i.e. laser beams whose states of polarization depend on the location in the beams' cross-section and commonly exhibit singularities, offer an extra degree of freedom in micro-structuring solids compared to conventional, homogeneously polarized laser light. Here we review our recent works in the synthesis, characterization and use of femtosecond laser vector beams for sub-diffraction-limit laser microfabrication. In particular, we demonstrate experimentally that the quality of light drilling depends strongly on the polarization structure of the pulses with radially polarized beams producing holes with smoother and better-delineated walls compared with the other polarizations used. We will also show that in a tight focusing geometry circularly polarized femtosecond laser vortex pulses ablate material differently depending on the handedness of light. This effect offers an additional degree of freedom to control the shape and size of laser-machined structures on a sub-wavelength scale.

### *11:35-12:00* **Angular Momentum of Light Forces Materials to Become Chiral Nano-Structures,** *Takashige Omatsu, Chiba University*

Laser beams termed 'Optical vortex' with a helical wavefront due to a phase singularity characterized by a quantum number, $m$, termed a topological charge, exhibit orbital angular momentum, $m\hbar$. A circularly polarized lights with a helical electric field also carry spin angular momentum, $s\hbar$. Thus, optical vortices with circular polarization also have a total angular momentum, $j\hbar$, defined as the vector sum of the orbital and spin angular momenta.

Such angular momenta, originated by the wavefront and polarization helicities of light, have widely received much attention in several fields, including optical trapping and guiding, as well as super resolution microscopy. Recently, we discovered that the angular momenta of light can be directly transferred to an irradiated metal sample, so as to form chiral nano-structures. This is the first demonstration, to the best of our knowledge, of nano-structured materials created by the angular momenta of lights. It is well known that a chiral structured array, such as a gammadion array acts as a chiral metamaterial with optical activity in the terahertz region. Thus, these chiral nan-structured materials fabricated by the angular momenta of the lights could provide plasmonic nanostructures and metamaterials with chiral selectivity. They will also enable us to distinguish selectively the chirality and

optical activity of molecules and chemical composites on the nanoscale. A key issue to fabricate such artificial optical devices based on chiral nano-structures formed by optical vortices is to design high power optical vortex lasers, and to extend their lasing frequency to interact with absorption bands of materials. To date, we have successfully developed a 1-μm high power optical vortex laser formed by a stressed large-mode-area fiber amplifier in combination with a solid-state master laser. We also demonstrated a milli-joule level, tunable 2-μm optical vortex and fractional optical vortex (with a non-integer charge) outputs from a 1-μm optical vortex pumped $KTiOPO_4$ (KTP) optical parametric oscillator. In particular, the 2-μm optical vortex lasers will allow us to fabricate chiral polymeric nanostructures. In this presentation, we review materials processing issues based on optical vortex lasers, which also addressing our state-of-art of vortex laser technologies.

***12:00-12:25 Harnessing Light for Sensing and Guiding at Mesoscales,*** *Aristide Dogariu, University of Central Florida*

Electromagnetic waves carry energy and momenta. The associated conservation laws in both propagation and scattering provide insights into phenomena such as spin transfer and power flow. In turn, these are essential for understanding the interaction of light with material structures of intermediate scales - structures that are too small to be described by traditional continuum methods, and too large to be regarded as simple dipoles. Such mesoscale phenomena occur in different circumstances, e.g., biological systems, soft materials, and fabricated mechanical nanostructures. We will review applications where controlling the coherence and polarization properties of electromagnetic fields offers unique capabilities for sensing material properties at mesoscales. Electromagnetic fields may also induce scale-specific modifications of material structures. In these situations, a passive and linear interpretation of the reciprocal action is inadequate. We will also show that harnessing light at scales comparable with the wavelength offers exclusive possibilities for controlling the mechanical action of light.

**12:25-13:25 Lunch [Provided]**

## Linear and Nonlinear Nanostructures

***13:25-13:50 Electrically Controlled Nonlinear Phenomena in Optical Metamaterials,*** *Wenshan Cai, Georgia Institute of Technology*

Metamaterials are commonly viewed as artificially-structured media capable of realizing arbitrary effective parameters, in which metals and dielectrics are delicately combined to facilitate the index contrast and plasmonic response required for a particular purpose. We aim to drive beyond this limited vision and explore the use of optical metamaterials as a generalizable platform for optoelectronic information technology: Metals will provide tailored plasmonic behavior as before, but will serve double duty by providing electrical functions including voltage input, carrier injection/extraction, and heat sinking, and dielectrics will consist of functional elements such as Kerr materials, electrooptic polymers, and p-n junctions. In this talk we will discuss our preliminary results on several topics in this category, including the electrically induced harmonic generation of light in a perfect metamaterial absorber, the active fishnet structure with electrical control, and the backward phase-matching in an optical metamaterial where the fundamental and frequency-doubled waves possess opposite indices of refraction.

***13:50-14:15 Harmonic Resonance Cones in Hyperbolic Metamaterials,*** *Domenico de Ceglia, National Research Council*

We show double resonance cones in nonlinear media with hyperbolic dispersion. The signal generated at harmonic frequencies by an electric dipole on the surface of the structure is scattered into two volume plasmon-polaritons. In particular, one part of the harmonic signal propagates within its own resonance cone, the other part is *phase-locked* to the fundamental signal and it is trapped under the pump's resonance cone. The large angular divergence between the two volume plasmon-polaritons is due to the metamaterial dispersion and birefringence. We predict this phenomenon both in discrete metal-dielectric stacks and in its homogenized, anisotropic version based on the effective medium approximation. We highlight the similarities and the differences between these two systems and discuss the limitations of the effective medium approximation.

***14:15-14:40 Nonlinear Optical Interactions in Plasma Resonant Materials,*** *Maria Antonetta Vincenti, National Research Council*

We investigate harmonic generation processes in material slab operating in the vicinity of their plasma resonances. Thanks to the near-zero permittivity values and extreme local field enhancement we show that we can boost nonlinear processes without resorting to any photonic resonant mechanism. Moreover, when multiple plasma resonant condition are present for the pump and its harmonic frequencies pump depletion can occur even for $kW/cm^2$ incident powers and very low susceptibility values. These highly-efficient nonlinear processes are possible in the presence of losses and phase-mismatch in structures that are $10^4$ times shorter than typical KDP or $LiNbO_3$ crystals, for relatively low irradiance values. Finally, in order to account for materials that do not possess any intrinsic, quadratic or cubic nonlinear terms or materials exhibiting great losses at the harmonic frequencies we show how nonlinear surface terms due to symmetry breaking and phase locked harmonic components should not be neglected in such extreme environments. Extremely low-threshold bistability and switching for materials with near-zero permittivity values will be also discussed.

***14:40-15:05 Backward Waves in Metamaterials,*** *Ildar Gabitov, University of Arizona*

Generation of backward waves is one of the characteristic manifestations of the nonlinear behavior of electromagnetic radiation in structured materials. This phenomenon is well studied and described in the literature. An example is the second-harmonic generation in nonlinear metamaterials. To date, most of the papers on this subject are limited to the case of scalar fields. In this paper, we consider the case of vector fields in the continuous wave approximation as well as for electromagnetic pulses.

***15:05-15:30 Towards Fabrication of Right-Sized Nanostructured Metamaterials,*** *Alexander Cartwright, University at Buffalo, SUNY*

Metamaterials are predicted to enable fundamentally new incarnations of many linear and nonlinear optical phenomena. Nanostructured metamaterials offer unique opportunities for achieving unprecedented control over light propagation. Most of these applications, especially those exploiting optical properties, require both efficient light in/out coupling and large-scale, tunable, three-dimensional structures. In this talk, we will focus on the use of focused ion beam writing to create structures that have high uniformity and repeatability over areas sufficiently large to interact with the entire optical beam (e.g., over a fiber core or a focused beam in free space). In addition, we will present the fabrication of 3-D structures that cannot be easily realized by conventional planar lithography. Finally, we will present some initial work on holographic photo-patterning to provide a simple and low-cost way to fabricate large areas of ordered thick structures using multi-pinhole illumination to produce complex periodic patterns. Challenges and opportunities of these fabrication methods will be presented.

***15:30-15:55 Plasmon Drag Effect in Metal Films and Nanostructures,*** *Natalia Noginova, Norfolk State University*

Significant photon drag effect is observed in thin metal films and nanostructures at the plasmon resonance conditions. In order to better understand the mechanism of the plasmon related photon drag, we study photoinduced electric currents in flat gold and silver films, and various nanostructures. Spectral dependence of the photoinduced electromotive force (emf) points to the major role of individual localized plasmon resonances in the emf generation. Possibility to engineer the magnitude and polarity of emf with nanoscale geometry is demonstrated.

## Closing Remarks

***15:55-16:00 Rich Hammond, United States Army Research Laboratory***

***The following people will have posters on display throughout the day.***

- *Garreth Ruane, Rochester Institute of Technology*
- *Mikhail Shalaev, University at Buffalo, The State University of New York*
- *Jingbo Sun, University at Buffalo, The State University of New York*
- *Xi Wang, University of Buffalo, The State University of New York*
- *Jinwei Zeng, University at Buffalo, The State University of New York*

| OSA Incubator Structured Light in Structured Media: From Classical to Quantum Optics | | | | |
|---|---|---|---|---|
| First Name | Last Name | Company | Country | Email |
| Andrei | Afanasev | George Washington University | United States | afanas@gwu.edu |
| David | Andrews | University of East Anglia Norwich | United Kingdom | D.L.Andrews@uea.ac.uk |
| Konstantin | Bliokh | Institute of Radio Astronomy | Ukraine | k.bliokh@gmail.com |
| Robert | Boyd | University of Ottawa/University of Rochester | Canada | boyd@optics.rochester.edu |
| Etienne | Brasselet | Université de Bordeaux | France | e.brasselet@loma.u-bordeaux1.fr |
| Wenshan | Cai | Georgia Institute of Technology | United States | wcai@gatech.edu |
| Alex | Cartwright | University at Buffalo, The State University of New York | United States | anc@buffalo.edu |
| Dominique | Dagenais | National Science Foundation | United States | ddagenai@nsf.gov |
| Domenico | de Ceglia | National Research Council | United States | domenico.deceglia@gmail.com |
| Anton | Desyatnikov | Australian National University | Australia | asd124@physics.anu.edu.au |
| Aristide | Dogariu | University of Central Florida | United States | adogariu@creol.ucf.edu |
| Vladimire | Drachev | Purdue University | United States | vdrachev@purdue.edu |
| Nader | Engheta | University of Pennsylvania | United States | engheta@ee.upenn.edu |
| Rene | Essiambre | Alcatel-Lucent | United States | Rene.Essiambre@alcatel-lucent.com |
| Michael | Fiddy | University North Carolina, Charlotte | United States | mafiddy@uncc.edu |
| Sonja | Franke-Arnold | University of Glasgow | United Kingdom | sonja.franke-arnold@glasgow.ac.uk |
| Ildar | Gabitov | University of Arizona | United States | ildar.gabitov@gmail.com |
| Qiaoqiang | Gan | University of Buffalo, The State University of New York | United States | qqgan@buffalo.edu |
| Daniel J. | Gauthier | Duke University | United States | gauthier@phy.duke.edu |
| Patrice | Genevet | Harvard University | United States | pgenevet@seas.harvard.edu |
| Richard | Hammond | United States Army Research Laboratory | United States | richard.t.hammond10.civ@mail.mil |
| Joseph | Haus | University of Dayton | United States | Joseph.Haus@notes.udayton.edu |
| Guarav | Jayaswal | University of Padova | Italy | gauravjswl1@gmail.com |
| Eric | Johnson | Clemson University | United States | ejohns8@clemson.edu |
| Wieslaw | Królikowski | Australian National University | Australia | wzk111@rsphysse.anu.edu.au |
| Zhaxylyk | Kudyshev | University of Buffalo, The State University of New York | United States | zhaxylyk@buffalo.edu |
| Yong-qing | Li | East Carolina University | United States | liy@ecu.edu |
| Jinda | Lin | East Carolina University | United States | linj@ecu.edu |
| Natasha | Litchinitser | University at Buffalo, The State University of New York | United States | natasha.litchinitser@gmail.com |
| Yongmin | Liu | Northeastern University | United States | y.liu@neu.edu |
| Giovanni | Milione | City College of New York | United States | giomilione@gmail.com |
| Tania | Moein | University of Bufallo, The State University of New York | United States | taniamoe@buffalo.edu |
| Gabriel | Molina-Terriza | Macquarie University | Australia | gabriel.molina-terriza@mq.edu.au |

| OSA Incubator Structured Light in Structured Media: From Classical to Quantum Optics | | | | |
|---|---|---|---|---|
| **First Name** | **Last Name** | **Company** | **Country** | **Email** |
| Mikhail | Noginov | Norfolk State University | United States | mnoginov@nsu.edu |
| Natalia | Noginova | Norfolk State University | United States | nnoginova@nsu.edu |
| Takashige | Omatsu | Chiba University | Japan | omatsu@faculty.chiba-u.jp |
| Miles | Padgett | University of Glasgow | United Kingdom | Miles.Padgett@glasgow.ac.uk |
| Viktor | Podolskiy | University of Massachusetts, Lowell | United States | Viktor_Podolskiy@uml.edu |
| Siddharth | Ramachandran | Boston University | United States | sidr@bu.edu |
| Martin | Richardson | University of Central Florida | United States | mcr@creol.ucf.edu |
| Garreth | Ruane | Rochester Institute of Technology | United States | gjr8334@rit.edu |
| Halina | Rubinsztein-Dunlop | University of Queensland | Australia | halina@physics.uq.edu.au |
| Yisa | Rumala | Institute for Ultrafast Spectroscopy and Lasers, City College-CUNY | United States | yrumala@yahoo.com |
| Ryan | Scott | University of California, Davis | United States | rpscott@ucdavis.edu |
| Vlad | Shalaev | Purdue University | United States | shalaev@purdue.edu |
| Mikhail | Shalaev | University at Buffalo, The State University of New York | United States | mshalaev@buffalo.edu |
| Jingbo | Sun | University at Buffalo, The State University of New York | United States | jingbosu@buffalo.edu |
| Grover | Swartzlander | Rochester Institute of Technology | United States | grover.swartzlander@gmail.com |
| Nickolas | Vamivakas | University of Rochester | United States | nick.vamivaka@rochester.edu |
| Maria Antonetta | Vincenti | National Research Council | United States | vincentiantonella@gmail.com |
| Xi | Wang | University of Bufallo, The State University of New York | United States | xw28@buffalo.edu |
| Abbie | Watnik | Naval Research Laboratory | United States | abbie.watnik@nrl.navy.mil |
| Alan | Willner | University of Southern California | United States | willner@usc.edu |
| Jie | Yao | University of California, Berkeley | United States | yaojie@berkeley.edu |
| Xiaobo | Yin | University of California, Berkeley | United States | xbyin2000@gmail.com |
| John | Zavada | National Science Foundation | United States | jzavada@nsf.gov |
| Jinwei | Zeng | University at Buffalo, The State University of New York | United States | jzeng@buffalo.edu |
| Shuang | Zhang | University of Birmingham | United States | s.zhang@bham.ac.uk |
| Lei | Zhou | Fudan University | China | phzhou@fudan.edu.cn |

# PARTICIPANT BIOGRAPHIES

**Andrei Afanasev**

Andrei Afanasev is currently the Gus Weiss Chair of Theoretical Physics; Lead Physicist, GW Energy Research Initiative, in the Department of Physics, The George Washington University (GWU). Professor Afanasev spent a significant part of his career as a scientist at Thomas Jefferson Accelerator Facility, one of the National Laboratories of the Department of Energy. He made significant research contributions in the field of nuclear and particle physics probed with high-power electron accelerators and free-electron lasers. He also proposed and developed new solutions for high-efficiency solar cells. Professor Afanasev an author of over 100 scientific papers and an editor of two books, "Radiation Acoustics" and "Physics with CEBAF at Jefferson Lab". Andrei Afanasev currently leads the physics effort for the GWU energy initiative and he is a Director of the Photoemission Research Laboratory in GWU. His special interests are focused on the role of orbital angular momentum in quantum physics. He received his Ph.D. Physics (1990) from Kharkov National University, Ukraine and his research areas include: Nuclear & Particle Physics; Photonics & Photovoltaics; Physics of Particle Accelerators.

**David L. Andrews**

David L. Andrews is a Professor of Chemical Physics at the University of East Anglia in the UK, where his internationally renowned theory group conducts research in fundamental photonics, optomechanical forces, optical vortices, nonlinear optics, energy harvesting and molecular energy transport. He has over 300 research papers to his name and a dozen books including the recent 'Structured Light and Its Applications'. Andrews is a Fellow of the Institute of Physics, the Royal Society of Chemistry, and SPIE - the international optics and photonics society. He is also a member of the Board of Directors at SPIE, and 2013-2014 Chair of the Photonics West OPTO Symposium.

**Konstantin Bliokh**

Konstantin Bliokh received his M.Sc. and Ph.D. in physics from Kharkov National University in 1998 and 2001. In 2001–2009, he worked at the Institute of Radio Astronomy in the Ukraine and collaborated with a number of scientific groups worldwide. Dr. Bliokh was a post-doctoral fellow from 2003–2006 at Bar-Ilan University in Israel, a Linkage International research fellow from 2008–2009 at the Australian National University and a Marie Curie research fellow from 2009–2011 at the National University of Ireland. Starting in 2011, he became a senior researcher at the Advanced Science Institute, RIKEN in Japan. His ongoing research areas include: geometric phases; spin-orbit interactions; optical angular momentum; wave propagation, localization, and scattering in inhomogeneous and random media; dynamics of spins and vortices in external fields (Hall and Magnus effects); quantum weak measurements; relativistic wave equations; electron vortices; adiabatic, WKB, geometrical optics theories; optical currents, polarization, and singularities; plasmonics and metamaterials; coupling and resonances. His scientific results have been published in 73 per-reviewed full-length papers (more than 1200 citations), 4 book chapters, and presented in numerous conferences and workshops.

**Robert W. Boyd**

Robert W. Boyd was born in Buffalo, New York. He received the B.S. degree in physics from MIT and the Ph.D. degree in physics from the University of California at Berkeley. His Ph.D. thesis was supervised by Charles Townes and involves the use of nonlinear optical techniques in infrared detection for astronomy. Professor Boyd joined the faculty of the University of Rochester in 1977, and in 2001 became the M Parker Givens Professor of Optics and Professor of Physics. In 2010 he became Professor of Physics and Canada Excellence Research Chair in Quantum Nonlinear Optics at the University of Ottawa. His research interests include studies of "slow" and "fast" light propagation, quantum imaging techniques, nonlinear optical interactions, studies of the nonlinear optical properties of materials, and the development of photonic devices including photonic biosensors. Professor Boyd has written two books, co-edited two anthologies, published over 300 research papers (≈10,000 citations, Google H-index 62), and been awarded nine patents. He is the 2009 recipient of the Willis E. Lamb Award for Laser Science and Quantum Optics. Professor Boyd is a fellow of the American Physical Society (APS) and of the Optical Society (OSA). He is a past chair of the Division of Laser Science of APS and has been a member of the Board of Directors of OSA. He has also served as an APS representative and chair of the Joint Council on Quantum Electronics (it is joint among APS, OSA and IEEE/LEOS). Professor Boyd has served as a member of the Board of Editors of Physical Review Letters and of the Board of Reviewing Editors of Science Magazine.

**Etienne Brasselet**

Etienne is a researcher at the Raul Pascal the University of Bordeaux in France. He leads the Singular Optics & Liquid Crystals group at "Laboratoire Ondes et Matière d'Aquitaine", which focuses on light-matter interaction in the presence of wave or material singularities. His research interests include optical vortices, optical forces and torques, spin-orbit interaction of light, liquid crystal topological defects, and structured media for photonics applications.

**Wenshan Cai**

Dr. Wenshan Cai joined the faculty of the Georgia Institute of Technology in January 2012 as an Associate Professor in Electrical and Computer Engineering, with a joint appointment in Materials Science and Engineering. Prior to this, he was a postdoctoral fellow in the Geballe Laboratory for Advanced Materials at Stanford University. His scientific research is in the area of nanophotonic materials and devices, in which he has made a major impact on the evolving field of plasmonics and metamaterials. Dr. Cai has published ~30 papers in peer-reviewed journals, and the total citations of his recent papers have reached approximately 3,000 within the past five years. He authored the book *Optical Metamaterials: Fundamentals and Applications* (Springer, 2009) which is used as a textbook or a major reference at many universities around the world. Dr. Cai received his B.S. and M.S. degrees from Tsinghua University in 2000 and 2002, respectively, and his Ph.D. from Purdue University in 2008, all in Electrical/Electronic Engineering.

**Alexander Cartwright**

Professor Cartwright is a full professor of Electrical Engineering and Biomedical Engineering at the University at Buffalo, The State University of New York. Cartwright's research interests are in ultrafast spectroscopy, optical lithography, semiconductor optoelectronics and optically active nanomaterials. Recently, his research efforts have focused on exploiting metamaterials to enable novel optical functionality in singular optics. Cartwright is a prior recipient of the NSF CAREER award, the Office of Naval Research Young Investigator Award and the SUNY Chancellor's Award for Excellence in Teaching. Cartwright received his PhD from the University of Iowa in 1995. He is currently serving as the Vice President for Research and Economic Development at the University at Buffalo.

**Dominique Dagenais**

Dominique M. Dagenais is Associate Program Director in the Electronics, Photonics and Magnetic Devices. Her interest is in Optoelectronics. After receiving her Diplôme d'Ingénieur from the Ecole Supérieure d'Optique in Orsay, France, she spent a year at the Institute of Optics, University of Rochester where she defended a thesis on uniform pellet illumination for Laser fusion. She then joined the French Atomic Energy Commission, working on high power Nd:YAG laser propagation, before coming to the Boston area, where she developed beam shaping optics for CO2 lasers at the AVCO Everett laboratories. In 1987 she joined the Naval Research Laboratory Optical Sciences division where she helped design and deploy the first three-axis fiber magnetic sensor, and demonstrated record sensitivity.

In 1999 she joined Alcatel and supported the development of novel optoelectronic active and passive devices for WDM fiber telecommunication. Ms Dagenais has two patents and over 50 refereed journal publications. As a member she has been actively involved with the IEEE Photonics society and its local chapters.

**Domenico de Ceglia**

Domenico de Ceglia is a National Research Council Senior Associate at US Army Aviation and Missile Research Development and Engineering Center (AMRDEC). He received his *Laurea* degree in Electronic Engineering from Politecnico di Bari in Italy in 2003 and he earned his Ph.D. with a thesis on nonlinear optical phenomena in photonic crystals and metamaterials from the same university in 2007. He was also a Research fellow at the Charles M. Bowden Laboratory, US Army AMRDEC at Redstone Arsenal, Alabama from 2005 to 2007, under several awards of the US Army Forward Element Command Atlantic. His main research interest is the study of novel linear and nonlinear phenomena in nanophotonic and nanoplasmonic devices, and in metamaterials.

**Anton S. Desyatnikov**

Dr. Anton S. Desyatnikov obtained the equivalent of PhD degree in physics from the Moscow Physical Engineering Institute in 2000. After completing post-doctoral work at the Australian National University (2000-2001), the Alexander von Humboldt Fellowship at Muenster University in Germany (2002-2003), and visiting fellowship at the Institut de Ciències Fotòniques (ICFO) in Spain (2004), he joined in 2004 the Nonlinear Physics Centre of the Research School of Physics and Engineering of the Australian National University. Dr Desyatnikov has co-authored 4 book chapters and more than 90 papers in refereed journals cited more than 2100 times (Scopus). Research interests include optical vortices and singular optics, nonlinear photonics, spatial optical solitons, as well as novel topological phenomena in optics, such as vortex knots and, more generally, emerging applications of structured light.

**Aristide Dogariu**

Professor Aristide Dogariu is the Florida Photonic Center of Excellence Professor at CREOL, The College of Optics & Photonics, at the University of Central Florida. He received his Ph.D. from Hokkaido University in Japan and his research interests include wave propagation and scattering, electromagnetism, optical sensing and imaging. He has published extensively in the broad area of optical physics and has served in a number of editorial positions. Professor Dogariu is a Fellow of the Optical Society and the Physical Society of America.

**Vladimir Drachev**

Dr. Vladimir P. Drachev (Associate Professor at the University of North Texas, Department of Physics) received his M.S. degree in physics from Novosibirsk State University, Russia, and the Ph.D. degree in experimental physics from Russian Academy of Sciences, Institute of Automation &Electrometry and Institute for Semiconductor Physics, in 1995. He was a Junior Scientist, Senior Scientist at the Institute for Semiconductor Physics, Visiting Scientist at New Mexico State University. His recent appointment as a Senior Research Scientist was at Birck Nanotechnology Center and School of Electrical and Computer Engineering, Purdue University (2002-2012). Dr. Drachev is an associate editor for Optical Materials Express, an OSA Senior Member. He is widely recognized for his works in nanophotonics and nanotechnology and, in particular for his experiments on optics, nonlinear optics, and spectroscopy of plasmonic nanostructures and their applications in biosensing and metamaterials.

**Nader Engheta**

Nader Engheta is the H. Nedwill Ramsey Professor at the University of Pennsylvania with affiliations in the Departments of Electrical and Systems Engineering, Bioengineering, Physics and Astronomy, and Materials Science and Engineering. He received his B.S. degree from the University of Tehran, and his M.S and Ph.D. degrees from Caltech. Selected as one of the *Scientific American Magazine 50 Leaders in Science and Technology* in 2006 for developing the concept of optical lumped nanocircuits, he is a

Guggenheim Fellow, an IEEE Third Millennium Medalist, a Fellow of IEEE, APS, OSA, the AAAS and SPIE, and the recipient of the 2013 *SINA Award*, 2013 *Benjamin Franklin Key Award*, 2012 *IEEE Electromagnetics Award,* 2008 *George H. Heilmeier Award for Excellence in Research*, *Fulbright Naples Chair Award*, *NSF Presidential Young Investigator award*, *UPS Foundation Distinguished Educator term Chair*, and also several teaching awards including the *Christian F. and Mary R. Lindback Foundation Award, S. Reid Warren, Jr. Award* and *W. M. Keck Foundation Award*. His current research activities span a broad range of areas including metamaterials and plasmonics, nanooptics and nanophotonics, graphene photonics, nonreciprocal optics, imaging and sensing inspired by eyes of animal species, miniaturized antennas and nanoantennas, physics and reverse-engineering of polarization vision in nature, mathematics of fractional operators, and physics of fields and waves phenomena. He has co-edited (with R. W. Ziolkowski) the book entitled "*Metamaterials: Physics and Engineering Explorations*" by Wiley-IEEE Press, 2006. He was the Chair of the Gordon Research Conference on Plasmonics in June 2012.

**René-Jean Essiambre**

René-Jean Essiambre received his B.Sc. and Ph.D. degrees in Physics and Optics, from the Université Laval inCanada, in 1988 and 1994, respectively. During his Ph.D. studies, he spent a year at McGill University, Montréal, QC, Canada, where he was engaged in research on solid-state physics. From 1995 to 1997, he was a Postdoctoral Fellow with Professor Agrawal at The Institute of Optics at the University of Rochester. Since 1997, he has been at Bell Laboratories, Alcatel-Lucent in New Jersey. His early research interests include on optical switching, soliton communication systems, high-power fiber lasers, and mode-locked fiber lasers. His current research interests include high-speed transmission (100 Gb/s and above) and physical layer design of fiber-optic communication systems, including Raman amplification, Rayleigh backscattering, fiber nonlinearities, advanced modulation formats, information theory, coding, space-division multiplexing in fibers supporting multiple spatial modes, nonlinear effects in such fibers, and network design. He is the author and co-author of more than 150 scientific publications and several book chapters. He has served as member and chair of many conference committees including ECOC, OFC, CLEO, and LEOS. He is general co-chair of CLEO: Science and Innovations 2014. Dr. Essiambre is a Fellow of the OSA and the IEEE, the recipient of the 2005 OSA Engineering Excellence Award and Distinguished Member of Technical Staff at Bell Laboratories.

**Michael Fiddy**

Michael Fiddy received his Ph.D. from the University of London in 1977, and was a research fellow in the Department of Electronic and Electrical Engineering at the University College of London before becoming a faculty member at London University (Kings College) in 1979. He moved to the University of Massachusetts Lowell in 1987 where he was ECE Department Head from 1994 until 2001. In January 2002 he was appointed the founding director of the Center for Optoelectronics and Optical Communications at UNC Charlotte. He stepped down from this position in 2010 to go on sabbatical leave, taking positions in New Zealand and Singapore. He is currently site director for the National Science Foundation's Industry/University Center for Metamaterials which began in 2011.

He has been a visiting professor at the Institute of Optics in New York, at the Department of mathematics at Catholic University, at the Nanophotonics Laboratory at Nanyang Technical University in Singapore and ECE Dept. U. of Christchurch, NZ. He has also been the editor-in-chief of the journal Waves in Random and Complex Media since 1996, and holds editorial positions with several other academic journals. He was the topical editor for signal and image processing for the journal of the Optical Society of America from 1994 until 2001 and is now the Deputy Editor of OSA's Photonics Research Journal. He currently serves as Chair-elect of OSA's Meetings Council and on the Advisory Board and Council of the Optoelectronics Industry Development Association. He has chaired 20 conferences in his field, and is a fellow of the OSA, IOP and SPIE and senior member IEEE. His research interests are inverse problems related to super-resolution imaging and metamaterial design.

**Sonja Franke-Arnold**

After studying in Hannover (Germany) as an undergraduate, Sonja received a Ph.M. in theoretical quantum optics from Strathclyde University in Scotland in 1994 and a Dr. rer. nat. from Innsbruck University in Austria in 1999. Since then she has been working in Glasgow on a variety of Personal Research Fellowships, first at Strathclyde University and since 2005 at Glasgow University, in the Optics Group, where she lectures. She is interested in structured light beams, in particular those that carry orbital angular momentum and has published over 50 articles in this field, including work on the angular uncertainty relation and the rotary photon drag. Currently, her main research effort is in experimental atom optics. Using rubidium atoms cooled to hundred Microkelvin above absolute zero, her group studies the manipulation of these atoms with novel light beams. This work is supported by a grant from the European Union of which she is a Glasgow Principal Investigator. Her group has recently generated ultra-high atom densities in holographically addressed traps and are now using these dense atoms to interact with structured light beams.

**Ildar Gabitov**

Professor Gabitov earned his Diploma in Mathematical Physics in 1974 from Leningrad State University and continued on to receive a Ph.D. in Theoretical and Mathematical Physics from the Landau Institute of Theoretical Physics in 1984. Since then, he continues to hold a variety of professorships at Aston University in the UK, the Southern Methodist University, is an Associate member of the Los Almos National Laboratory, and is currently a Professor at the University of Arizona's Department of Mathematics. Professor Gabitov has more than 70 publications and holds 2 patents. Professor Gabitov possesses extensive editing experience, having held positions as editor for a variety of journals, including Physica D and SIAM Journal. He has also been a reviewer for many organizations, such as, the U.S. Army Research Office, the Engineering and Physical Sciences Research Council and The United States-Israel Binational Science Foundation. He became an Optical Society Fellow in 2012 and earned a series of awards and fellowships prior.

**Qiaoqiang Gan**

Dr. Qiaoqiang Gan is an Assistant Professor in the Department of Electrical Engineering at University at Buffalo, The State University of New York. He received his Bachelor's degree from Fudan University, China in 2003, his Master's degree in 2006 in nanophotonics at the Nano-Optoelectronics Lab in the Institute of Semiconductors at the Chinese Academy of Sciences, and his PhD degree from Lehigh University in 2010. He received IEEE Photonic Society Student Fellowship Award and Chinese Government Scholarship for Graduate Students Abroad in 2009. In 2013, he received the award of "Innovations that could change the way you Manufacture" from Society of Manufacture Engineers. His current research interests include nanophotonics, plasmonics, and bio-photonics. His research publications include over 60 technical papers and 4 patents.

**Daniel J. Gauthier**

Professor Gauthier is the Robert C. Richardson Professor of Physics at Duke University. He received his B.S., M.S., and Ph.D. degrees from the University of Rochester in 1982, 1983, and 1989, respectively. His Ph.D. research on "Instabilities and chaos of laser beams propagating through nonlinear optical media" was supervised by Professor R.W. Boyd and supported in part through a University Research Initiative Fellowship. From 1989 to 1991, he developed the first CW two-photon optical laser as a Post-Doctoral Research Associate under the mentorship of Professor T. W. Mossberg at the University of Oregon. In 1991, he joined the faculty of Duke University as an Assistant Professor of Physics and was named a Young Investigator of the U.S. Army Research Office in 1992 and the National Science Foundation in 1993. He was chair of the Duke Physics Department from 2005 - 2011 and is a founding member of the Duke Fitzpatrick Institute for Photonics. His research interests include: high-rate quantum communication, nonlinear quantum optics, single-photon all-optical switching, applications of slow light in classical and quantum information processing, and synchronization and control of the dynamics of complex networks in complex electronic and optical systems. Professor Gauthier is a Fellow of the Optical Society and the American Physical Society.

**Patrice Genevet**

Patrice Genevet was born in Nice, in France, in 1982. He received his PhD degree in Physics from the university of Nice-Sophia-antipolis, France in 2009. His thesis work was in the area of nonlinear dynamics and localized spatial solitons in semiconductor lasers. In 2009, he joined the Capasso's group at Harvard University in collaboration with Prof. M.O. Scully in Texas A&M University to work on nonlinear plasmonics and metasurfaces. Since 2011, He is a research associate at Harvard University in the group of Prof. Capasso. His research interests include semiconductor lasers, nanophotonics, plasmonics, metamaterials, metasurfaces, thinfilms, nonlinear optics and nonlinear dynamics. He contributed to 35 refereed international papers and co-authored 4 book chapters. He holds three US patents.

**Richard Hammond**

Richard Hammond is a theoretical physicist and program manager for the United States Army Research Office. He is an Adjunct Professor at the University of North Carolina at Chapel Hill and the author of the book "The Unknown Universe: The Origin of the Universe, Quantum Gravity, Wormholes, and Other Things Science Still Can't Explain" and other popular science books. He has published numerous scientific articles in a wide range of fields, from general relativity to quantum mechanics, and has pioneered a new theory of gravitation that has won international acclaim. He has won awards from NASA for his research and teaching, international awards for research on gravity, and was invited to Cal Tech's Jet Propulsion Lab to study solar system tests of Einstein's theory.

**Joseph W. Haus**

Joseph W. Haus has served as Director of the Electro-Optics Program at the University of Dayton for 13 years and is the founding Director of the Ladar and Optical Communications Institute. He is a Fellow of the OSA, SPIE and APS and has participated on many conference committees for OSA and SPIE. In particular he is a founding co-chair of the International Conference on Nanophotonics (ICNP) which is an OSA Topical Conference. His research is in the area of heterogeneous materials where he has published papers on their linear and nonlinear optical properties. The optical materials work includes quantum and electromagnetic properties of heterostructured nanoparticles, photonic crystals, and recently metamaterials. He has also published contributions to high gain nonlinear optical materials, fiber optic lasers, digital holography and coherent laser radar.

**Gaurav Jayaswal**

Gaurav Jayaswal obtained his Bachelors of Technology in “Electronics and Telecommunication” from Biju Patnaik University of Technology in India. Currently, he is working on “Microfluidics” as a Ph.D. student in the Department of Physics at the University of Padova in Italy. His Ph.D. project focused on “Fabrication of microfluidics devices for the study of active matters”. This work focuses on the fabrication of microfluidics channels for flow of active matters. In the past, he had worked in the fabrication of “Future generation coherent electronic circuit development” at Scuola Normale Superiore-National Enterprise of Nano-Science and Nano-Technology in Italy. He has also worked as a Junior Research Fellow at Tata Institute of Fundamental Research in India, where he was trained to work on various instruments like Atomic layer deposition (ALD), Reactive Ion Etching (RIE), Chemical Vapor Deposition (PECVD), metal evaporator and spinners in a Class1000 clean room. During his B.Tech internship he worked on Pulse laser deposition system at the National university of Singapore.

To this date he has published the following works: Journal paper “ Weak measurement of the Goos-Hanchen shift” G. Jayaswal, G. Mistura and M. Merano in Optics letters vol 38, issue 8, pp 1232-1234 (2013); “Design and simulation of millimeter wave micro-strip line” accepted in the International Journal of Research Science and Engineering; Project entitled “Photoelectron Spectrometer” in Indian Physics Association (National Journal-2008);

Conference Paper: Sachin Kasture, Gaurav Jayaswal, A.Mohan, A.V.Gopal " Fabrication and Characterization of Metallo-Dielectric Structure" International Conference (TIFR, India and ANL USA meet) Published (02/2010).

**Eric Johnson**

As the PalmettoNet Endowed Chair in Optoelectronics, Eric Johnson serves as the head of the South Carolina SmartState Center of Economic Excellence in Optoelectronics. Before joining Clemson, Dr. Johnson held a joint appointment as a Professor of Physics and Optical Science as well as Electrical and Computer Engineering at the University of North Carolina at Charlotte, also serving as the Director of the Center for Optoelectronics and Optical Communications. He was previously an Associate Professor at the College of Optics and Photonics/CREOL at the University of Central Florida, and was the Vice President of Research and Development at the Digital Optics Corporation. Dr. Johnson has also held various other positions in industry for development, engineering, and management.

Dr. Johnson has served on the Board of Directors for SPIE and has served on various committees for scholarship, conferences, and technical programs within SPIE. He is currently an Ex-Officio member on IEEE's EDS Optoelectronic Devices Committee. He was also a former Chair for the Optics in Information Science Division of OSA and the former OSA Technical Group Chair for Holography and Diffractive Optics. He is currently a Topical Editor for Applied Optics and the previous Associate Editor for SPIE's Journal of MEMS. He is a Fellow of OSA, SPIE, and a Senior Member of IEEE. Dr. Johnson has a Ph.D. in Electrical Engineering from the University of Alabama at Huntsville, M.S. in Electrical Sciences from the University of Central Florida, and B.S. in Physics from Purdue University.

Dr. Johnson's research spans the area of micro-optics and nano-photonics, with particular emphasis on active and passive photonic devices. Some of his major innovations include the development of methods for fabricating 3-Dimensional micro- and nano-optics (Meta-Optics), high power lasers, novel integrated fiber beam shaping devices utilizing multimode interference, sensors, fiber lasers, data communications, and passive optics for spectral and polarization filtering. He has over 130 publications in the field with 12 issued patents. He has received over $15,000,000 in externally funded university and small business research. He was a recipient of NSF's CAREER Award and has been funded by DARPA, AFOSR, ONR, and numerous industrial organizations.

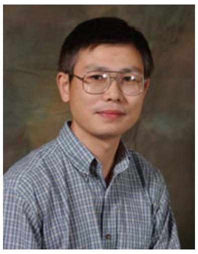
**Wieslaw Królikowski**

Wieslaw Krolikowski received his PhD from the Institute of Physics, Polish Academy of Sciences in 1988. From 1988 till 1991 he worked as Research Associate at the Electro-optics Technology Center, Tufts University. From 1992 he has been working at the Laser Physics Centre, Australian National University in Canberra, Australia, currently as a Head of Department. His research interests include nonlinear optics, soliton physics, nonlinear dynamics and integrated optics. For his contributions to the field of nonlinear optical phenomena W. Krolikowski was in 2013 awarded an Honorary Doctorate by the Technical University of Denmark. Dr. Krolikowski is a Fellow of the Optical Society of America.

**Zhaxylyk Kudyshev**

Zhaxylyk Kudyshev is a postdocorate with Professor Litchinitser's group at the State University of New York in Buffalo. He received his Bachelor's degree in physics in 2007, his Master's degree in optics and plasmaphysics in 2009 and his Ph.D. in physics from al-Farabi Kazakh National University, in Kazakhstan. His dissertation work was supervised by Professor I.R. Gabitov (University of Arizona,Tucson, USA) and Professor F.B. Baimbetov (al-Farabi Kazakh National University, Almaty,Kazakhstan). He has authored more than 15 journal and conference research papers. His research interests include linear and nonlinear optics in metamaterials and plasma physics.

**Yong-qing Li**



Yong-qing Li received the B.S. degree in physics from the Zhongshan University, Guangzhou, P.R. China, in 1983, and the Ph.D. degree in physics from Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, China, in 1989. He had his post-doc trainings at Max-Planck-Institute for Quantum Optics, Garching, Germany, University of Canberra, Australia, and University of Arkansas in Fayetteville, Arkansas. Since 1999, he has joined the faculty in the department of physics, East Carolina University, Greenville, North Carolina, USA. He is currently a Professor of physics at East Carolina University. Professor Li's research is in the field of biomedical optics and quantum optics. His research has been focused on laser tweezers Raman spectroscopy (LTRS), confocal Raman micro-spectroscopy and molecular imaging based on multi-foci scanning of the structured laser beams, monitoring biological dynamics and heterogeneity of single living cells and spores, characterization of biological and chemical aerosols using LTRS, electromagnetically induced transparency and quantum noise reduction of squeezed light. He is a senior member of the Optical Society (OSA) and a member of American Society for Microbiology.

**Jinda Lin**

Jinda Lin received the B.S. degree in physics from the Nanjing University, Nanjing, P.R. China, in 2008, and the Ph.D. degree in physics from Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, China, in 2013. He currently has his post-doc trainings at East Carolina University, Greenville, North Carolina, USA. Dr. Lin's research is in the field of biomedical optics and quantum optics. His research has been focused on laser tweezers Raman spectroscopy (LTRS), confocal Raman micro-spectroscopy, monitoring biological dynamics and heterogeneity of single living cells and spores, characterization of biological and chemical aerosols using LTRS.

**Natalia M. Litchinitser**

Natalia M. Litchinitser is an Associate Professor of Electrical Engineering at The State University of New York in Buffalo. She previously held a position as a Member of Technical Staff at Bell Laboratories, Lucent Technologies and as a Senior Member of Technical Staff at Tyco Submarine Systems. Natalia Litchinitser's research interests include linear and nonlinear optics, metamaterials, singular optics, chaos, and optical

communications. Natalia Litchinitser authored 5 invited book chapters, over 100 journal and conference research papers, and over 30 invited talks. She is a topical editor of the Journal of The Optical Society B and Optics Communications. She is a Fellow of the Optical Society and a Senior Member of the Institute of Electrical and Electronics Engineers.

**Yongmin Liu**

Yongmin Liu received his Ph.D. in Applied Science and Technology from UC Berkeley in 2009, and both his M.S. and B.S. degrees in Physics from Nanjing University in China in 2003 and 2000, respectively. Prior to joining the faculty of Northeastern University in 2009 with a joint appointment in Electrical & Computer Engineering and Mechanical & Industrial Engineering, he was a postdoctoral fellow at UC Berkeley from 2009 to 2012.

Dr. Liu's research interests include nano optics, nanoscale materials and engineering, nano devices, plasmonics, metamaterials, biophotonics, nano optomechanics, and nonlinear and quantum optics of metallic nanostructures. He has authored and co-authored over 30 journal papers including Science, Nature, Nature Nanotechnology, Nature Communications, Physical Review Letters and Nano Letters. Dr. Liu is the recipient of the Chinese Government Award for Outstanding Students Abroad in 2009, the International Society for Optical Engineering (SPIE) Scholarship Award in 2008, and the Tse-Wei Liu Memorial Fellowship at UC Berkeley in 2008.

**Giovanni Milione**

Giovanni Milione is a PhD student under Distinguished Professor Robert R. Alfano of the newly founded New York State Center for Complex Light, the Institute for Ultra fast Spectroscopy and Lasers, of the Physics and Engineering Departments of the City College of New York. Giovanni is a National Science Foundation Graduate Research Fellow and SPIE Optics and Photonics scholarship winner. Giovanni, originally from Long island New York, completed his Bachelors of Science in Physics at Stony Brook University after serving in the United States Army Reserve as part of Operation Iraqi Freedom. His research interests include the study of the fundamental properties of light's polarization - specifically vector beams, i.e., radial and azimuthal polarization, and their relationship to light's angular momentum, the interaction of light's angular momentum with matter via spectroscopy, and the use of light's angular momentum for free space and fiber optic communication. He is actively involved in the Optical Society, European Optical Society and SPIE student chapters.

**Tania Moein**

Ms. Tania Moein completed her bachelor's degree in Electrical Engineering from the University of Guilan, Iran in June 2008. She is currently a Ph.D. candidate at the University at Buffalo in the department of Electrical Engineering; where she is conducting research in the area of Optics and Photonics with special emphasis in nano-micro fabrication of periodic structure with holographic lithography.

During her Ph.D. study, she worked on a one-step, low-cost holographic lithography method to fabricate a polymer with extraordinary properties that fabricates a polymer with extraordinary properties that can significantly reduce the cost and size of the current state-of-

the-art multispectral analyser. Used as a filter for light, this material could form the basis of handheld multispectral imaging devices that identify the "true color" of objects examined. Accurate color detection, measuring spectral discrepancies in the nanometer range, has applications in anti-counterfeiting, remote sensing for military and defense applications, environmental, agricultural and climate monitoring, as well as microscopic bio-imaging.

Currently, she is president of the OSA Student Chapter of Buffalo, NY and she received a first award in poster competition in Department of Electrical Engineering, University at Buffalo.

**Gabriel Molina-Terriza**

Since January of 2012, Gabriel Molina-Terriza has held a Future Fellowship from the Australian Research Council. He is an Associate Professor at Macquarie University in Australia. There he leads an experimental research group called QIRON, which researches the interactions of light and matter at the nanoscale, focusing on applications to Quantum Metrology, Quantum Information and Nanophotonics. QIRON has been funded by the Australian Research Council, through the Discovery Project and the Center of Excellence programs. Dr. Molina-Terriza belongs to Engineered Quantum Systems of the Center of Excellence. Before his current position, he worked in several institutions around the world: ICFO, the University of Singapore, the University of Vienna, etc. Dr. Molina-Terriza earned his Ph.D. from the Polytechnic University of Catalonia in Spain in 2002.

**Mikhail A. Noginov**

Dr. Mikhail A. Noginov graduated from the Moscow Institute for Physics and Technology with a M.S. degree in Electronics and Automatics in 1985. In 1990, he received a Ph.D. degree in Physical-Mathematical Sciences from the General Physics Institute of the USSR Academy of Sciences. From 1985-1997, Dr. Noginov held research positions at theGeneral Physics Institute of the USSR Academy of Sciences, the Massachusetts Institute of Technology, and the Alabama A&M University. In 1997, Dr. Noginov joined Norfolk State University, where he currently serves as Professor. In 2010, Dr. Noginov was named Norfolk State University Eminent Scholar.

Dr. Noginov has published three books, six book chapters, over 120 papers in peer reviewed journals, and over 150 papers in proceedings of professional societies and conference technical digests. He has served as a chair of several conferences of SPIE and OSA, including CLEO Program Chair in 2013. Since 2003, Dr. Noginov has been a faculty advisor of the OSA student chapter at NSU. Dr. Noginov's Research interests include Metamaterials, Nanoplasmonics, Random Lasers, Solid-State Laser Materials, and Nonlinear Optics.

**Natalia Noginova**

Dr. Natalia Noginova is an Associate Professor in the Department of Physics and Center for Materials Research. Dr. Noginova has worked at Norfolk State University since 1997. Before that, she earned her Ph. D. in Physical-Mathematical Sciences, from the Institute of Radio Engineering and Electronics in Russia in 1993. Her research experience includes studies in materials science, condensed matter physics, magnetic resonance, and

optics. She has published about 70 peer reviewed papers and presented more than 90 conference talks, including several invited presentations.

Her main research expertise lies in the area of magnetic materials and magnetic resonance, however she is always open to new exciting ideas in other fields. Her current research interests are nanoscale magnetic systems and plasmonic metamaterials. Natalia Noginova successfully combines research with teaching. She actively participated in the development and implementation of the Ph.D. Program in Materials Science and Engineering, including the development and teaching of a new graduate course “Materials for Nanotechnology”. She is a coordinator of Norfolk State University’s Materials Science Seminar Series.

**Takashige Omatsu**

Dr. Omatsu received his Ph.D. in Applied Physics from the University of Tokyo in Japan in 1992 for research on the frequency- extension of metal vapour lasers and temporal evolution of spatial coherence in metal vapour lasers. He has been working high power solid-state lasers based on diode-pumped Nd doped vanadate bounce amplifiers, and has also been investigating the development of yellow-orange all solid-state Raman lasers.

He has currently been challenging to explore a novel research field, i.e., high-power vortex laser technology based on a solid-state as well as fiber lasers. His vortex laser technologies, including chirality control of nanostructures, will potentially provide a new scientific aspect to nano-scale material processing, metamaterials, teraheltz photonics, plasma photonics, and nonlinear spectroscopy. He has already published over 180 journal and conference papers, and he has performed over 60 invited presentations of international or domestic conferences.

He was appointed as an Associate Editor of Optics Express from 2006-2012 where he contribute to the spectacular growth of Optics Express. He is also on the editorial board of Applied Physics Express (The Japan Society of Applied Physics). He is currently working as a steering committee member of the conference on the laser and optoelectronics pacific-rim (CLEO Pacific-rim). He was awarded a Fellow of the Japan Society of Applied Physics in 2013.

**Miles Padgett**

Miles Padgett is a Professor of Optics in the School of Physics and Astronomy at the University of Glasgow. He heads a 15-person team covering a wide spectrum from blue-sky research to applied commercial development, funded by a combination of government and industry grants. In 2001, he was elected to the Fellowship of the Royal Society of Edinburgh. In 2007/8 he was a Leverhulme Trust, Royal Society Senior Research Fellow. Since 2009, he has held a Royal Society/Wolfson Merit Award. In 2011, he was appointed to the Kelvin Chair of Natural Philosophy and became a Fellow of the Optical Society. In 2012, he became a Fellow of SPIE.

In 2008, Padgett was awarded the UK Institute of Physics, Optics and Photonics Division Prize for a "distinguished record of achievement in research that spans fundamental aspects

of optical angular momentum and applied optical sensors". In 2009, Padgett was awarded the Institute of Physics, Young Medal "for pioneering work on optical angular momentum".

Padgett is recognized for his studies in the field of optics and in particular of optical angular momentum. His contributions include an optical spanner for spinning micron-sized cells, use of orbital angular momentum to increase the data capacity of communication systems and an angular form of the quantum Einstein-Podolsky-Rosen (EPR) paradox.

**Viktor Podolskiy**

Professor Viktor Podolskiy earned his B.S. degree in Applied Mathematics and Physics from the Moscow Institute for Physics and Technology in 1998, followed by his M.S. in Computer Science and Ph.D. in Physics from New Mexico State University in 2001 and 2002, respectively. Upon completion of his Ph.D. program, Dr. Podolskiy joined Electrical Engineering Department of Princeton University as a Post Doctoral Research Associate. Between Sep 2004 and Dec.2009 Dr. Podolskiy worked at the Physics Department of Oregon State University as an Assistant Professor, and later as an Associate Professor. In Jan 2010, Dr. Podolskiy joined the University of Massachusetts Lowell, where he is currently an Associate Professor at the Department of Physics and Applied Physics, and an Acting Director of the Photonics Center. Dr. Podolskiy's research is focused on theory and modeling of optical properties of nano- and micro-structured composites, metamaterials, and plasmonic systems. He has presented over 30 invited talks, and co-authored over 70 peer-reviewed publications, 60 conference proceedings, and 3 US patents.

**Siddharth Ramachandran**

Dr. Siddharth Ramachandran obtained his Ph.D. in Electrical Engineering from the University of Illinois, Urbana -Champaign, in 1998. Thereafter, he joined Bell Laboratories as a Member of the Technical Staff and subsequently continued with its spin-off, OFS Laboratories. After a decade in industry, Dr. Ramachandran has moved back to academics, and is now an Associate Professor in the Department of Electrical Engineering at Boston University. Professor Ramachandran's research focuses on the optical physics of guided waves. He has authored over 150 refereed journal and conference publications, more than 35 invited talks, plenary lectures and tutorials, 2 book-chapters, and has been granted over 30 patents. For his contributions in the field of fiber-optics, he was named a Distinguished Member of Technical Staff at OFS Labs in 2003, and a fellow of the Optical Society of America (OSA) in 2010. He served as a topical editor for Optics Letters from 2008-2011, and is currently an associate editor for the IEEE Journal of Quantum Electronics, in addition to serving on numerous conference and grant-review committees in the field of optics and applied physics.

**Martin Richardson**

Martin Richardson [BSc, ARCS, Imperial College (64), Ph.D, London Univ.(67)], has spent his whole career in high power lasers, laser-plasmas and applications of lasers. He has work in Canada at NRC, the University of Rochester, and is now Director of the Townes Laser Institute at UCF. He is also a Trustee Chair, a Pegasus Professor, and the Northrop-Grumman Professor of X-ray Photonics. In addition he has worked on sabbatical visits to universities and institutes in German, France, Japan, Australia, Qatar and the former Soviet Union. He has published over 400 scientific articles in professional scientific journals, and has presented numerous invited and plenary talks. He has written over a dozen book chapters and holds ~ 25 patents, with several pending and has chaired many international conferences including IQEC, ICHSP, and several SPIE meetings. He is a former Associate Editor of JQE, and serves on the Editorial Board of the LIA *"Journal of Laser Applications".* He is a recipient of the Schardin Medal, awarded by the German Physical Society, the Harold E. Edgerton of SPIE and is a Fellow of OSA and SPIE.

**Garreth Ruane**

Garreth Ruane received a B.S. in Physics from the State University if New York at Geneseo in 2011 and is currently a Ph.D. candidate at the Center for Imaging Science at the Rochester Institute of Technology. His experimental research involves the generation and control of light beams with phase and polarization singularities. Garreth has demonstrated the use of vortex phase optics in various areas of application, including high-contrast imaging, super resolution, and optical patterning. He is currently exploring applications of singular optical phenomena in metamaterials.

**Halina Rubinsztein-Dunlop**

Professor Rubinsztein-Dunlop received her Ph.D. from Göteborg University in Sweden and was awarded a Docent Degree from the same University. She is a professor of physics at the University of Queensland and leads two research groups: in quantum atom optics and laser micromanipulation. Halina is Head of the School of Mathematics and Physics and a Director of the Quantum Science Laboratory. Halina's research interests are in atom optics, laser micromanipulation, laser physics, linear and nonlinear high resolution spectroscopy, and nano-optics. She has published over 200 papers in international peer reviewed journals, ten book chapters and a large number of international conference papers and many invited presentations. Halina Rubinsztein-Dunlop is a Fellow of OSA and SPIE. She is a member of the Scientific Advisory Board of NTT Basic Research Laboratories in Japan, a member of the Editorial Boards of IOP Journal of Optics, Journal of Biophotonics, and a Member of the Advisory Board of Laser Beckmann Institute.

**Yisa S. Rumala**

Dr. Yisa S. Rumala is currently a Research Associate at the Institute for Ultrafast Spectroscopy and Lasers (IUSL) at City College -CUNY for which Professor Alfano is the Director. He earned his Ph.D. in Applied Physics and an M.S. degree in Electrical Engineering, from the University of Michigan, Ann Arbor, in addition to a B.S. degree in Physics and Mathematics as a dual major with highest honors from York College-CUNY. Dr. Rumala has completed research fellowships at Princeton University and the Massachusetts Institute of Technology. He has published articles in leading academic journals and serves as a peer reviewer to academic journals. He has also given numerous contributed and invited presentations of his research to both general and specialized audiences.

At the IUSL labs, Dr. Rumala performs research involving supercontinuum light generation, optical vortices, acoustics, and various other aspects of nonlinear optics and spectroscopy. Some of his previous research involved optical and atomic physics, Nuclear Magnetic Resonance, and Quantum Cascade Lasers. In addition to performing world class research, Dr. Rumala is interested in mentoring and teaching the next generation of leaders, and has participated IUSL science outreach and student mentoring activities, served as a science judge for UM physics Olympiad competitions, and performed science shows under the auspices of various professional organizations. He is a member of OSA, SPIE, and APS. Dr. Rumala has won several prestigious academic awards and honors, including the National Science Foundation fellowship award, Alfred P. Sloan Scholarship award, and most recently the Chancellor's Decade of Science Alumni Academic Achievement award for exemplary achievements in the Science, Technology, Engineering, and Mathematics disciplines awarded by the Chancellor of CUNY.

**Ryan P. Scott**

Dr. Ryan P. Scott is a Project Scientist in the Department of Electrical and Computer Engineering at University of California, Davis. He is currently the senior research scientist and laboratory manager for Professor Ben Yoo’s Next Generation and Networking Systems research group at UC Davis. He received his Ph.D. degree in Electrical and Computer Engineering from UC Davis in 2009 for experimental studies in laser noise measurement techniques and applications of spectral amplitude and phase encoding of femtosecond pulses. He has participated in multiple DARPA sponsored projects including O-CDMA, OAWG, Si-PhASER, QUINESS, SeeMe, and InPho. Dr. Scott has authored or co-authored more than 100 peer-reviewed journal publications and conference papers.

**Mikhail Shalaev**

During his high school education Mikhail became interested in physics and mathematics, and devoted much of his time and energy to developing his skills in these fields. Earning a B.S. in Applied Physics, Mikhail became interested in metamaterials as one of the most prospective field of optics with revolutionary impacts on present-day technology. As a result, he graduated with a M.S. degree from the Siberian Federal University and worked at the Coherent Optics Lab at the Kiresky Institute of Physics.

Mikhail is currently a Ph.D. student at the University at Buffalo and works in Professor Litchinitser’s group on metamaterials and singular optics fields. His research focuses on the theoretical description and numerical simulation of nonlinear optical processes in metamaterials. His is especially excited by the fact that computer simulation software is now available for modeling of nonlinear optical processes.

**Vladimir Shalaev**

Dr. Vladimir Shalaev is the Scientific Director of Nanophotonics at Birck Nanotechnology Center, and the Robert and Anne Burnett Distinguished Professor of Electrical and Computer Engineering, Purdue University. He received his Ph.D. from Krasnoyarsk State University (Russia), in physics and mathematics.

**Jingbo Sun**

Dr. Jingbo Sun is a postdoctor in Professor Natalia M. Litchinitser’s group at the State University of New York in Buffalo. In 2012, he earned his Ph.D. in Materials Science at Tsinghua University in China. In 2013, Dr.
Sun became a member of the Optical Society. His research interests cover singularity optics, hyperbolic materials, microwave devices based on metamaterials, cloak, metamaterial absorber and Direct-Write Assembly by ceramic ink.

**Grover Swartzlander**

Professor Swartzlander earned his Ph.D. from Johns Hopkins University in Baltimore, as well as, his M.S. in Electrical Engineering from Purdue University and his B.S. from Drexel University. He currently works as an Associate Professor at the Rochester Institute of Technology, where he is exploring experimental and theoretical topics in the field of physical optics. These include sub-resolution imaging, high contrast imaging, metamaterials, polarization holography, optical vortices, solar sailing, and radiation pressure forces and torques. He has conducted pioneering research on the optical vortex coronagraph, optical vortices, solitons, coherence theory, optical tweezers, and optical lift. He joined the Rochester Institute of Technology in 2008 after appointments at the University of Arizona, the Worcester Polytechnic Institute, and the US Naval Research Lab. He is a Fellow of the Optical Society, and serves on the Publications Council and also the Fellows Committee of the OSA. He has also been named a NIAC Fellow, and a Cottrell Scholar. Grover Swartzlander has recently been named Editor-in-Chief of the Journal of the Optical Society – B.

**Nickolas Vamivakas**

Nick Vamivakas studied Electrical Engineering at Boston University and received his PhD degree in 2007. During this time he developed high resolution microscopy and spectroscopy techniques to study the electro-optic properties of individual nanostructures. Following his PhD, he was a post-doc from 2007-2011 in the Cavendish Laboratory at the University of Cambridge. Nick joined the Institute of Optics in 2011 and currently is an Assistant Professor. Professor Vamivakas' research efforts center on light-matter interaction at the nanoscale. He is particularly interested in using optics to interrogate and control both artificial and naturally occurring solid-state quantum emitters. Potential applications range from optical metrology to quantum information science.

**Maria Antonietta Vincenti**

Maria Antonietta Vincenti is a Research Associate of the National Research Council at the U. S. Army Aviation and Missile Research Development and Engineering Center. She received her Laurea degree (summa cum laude) and Ph.D. in Electronic Engineering from Politecnico di Bari in Italy in 2005 and 2009, respectively. From 2007 to 2009 she also worked as a Research Fellow at the U.S. Army's Charles M. Bowden Laboratory at Redstone Arsenal under several awards sponsored by the U.S. Army Forward Element Command Atlantic. Her research activity focuses on theoretical investigations and the computational modelling of linear and nonlinear interactions in optical nanostructures, including plasmonic devices, optical sensors and novel sub-wavelength structures for light harvesting.

**Xi Wang**

Xi Wang is a Ph.D. candidate in the Department of Electrical Engineering at the State University of New York in Buffalo. He received his master's degree from the State University if New York in Buffalo in 2009 and his bachelor's degree from Tsinghua University in 2007. Xi Wang is a student member of OSA and has been the president of the Buffalo OSA chapter between 2012 and 2013. Xi Wang's research covers optical fiber based metamaterials, nonlinear metamaterials, hyperbolic metamaterials, optical vortex and ultrafast laser characterization system. He's also interested in semiconductor metamaterials and metasurface.

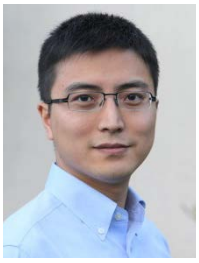
**Abbie Tippie Watnik**

Dr. Abbie Watnik is a Karle Fellow and Research Physicist in the Applied Optics Branch within the Optical Sciences Division at the Naval Research Laboratory in Washington, DC. Dr. Watnik's current work focuses on applying holographic and computational imaging techniques and principles to intelligence, surveillance and reconnaissance (ISR) systems and countermeasures (CM). Dr. Watnik's research interests include active imaging, diffractive imaging, optical vortices, aberration correction, phase reconstruction, mathematical algorithm development and non-conventional approaches to image correction. Dr. Watnik earned her Ph.D. and M.S. from the University of Rochester. As National Science Foundation Graduate Research Fellow and Harvey Fellow, Dr. Watnik studied aberration correction for multi-plane aberrations using a nonlinear optimization approach using sharpness metrics as well as constructed and processed gigapixel synthetic-aperture high-resolution imagery. She is recipient of the Rochester Precision Optics Award and winner of the Mark Ain Technical Business Model Competition. Dr. Watnik is a member of the Optical Society (OSA) and SPIE.

**Professor Alan Willner**

Professor Alan Willner received his Ph.D. in Electrical Engineering from Columbia University in 1988, as well as his B.A. in Physics in 1982 and an Honorary Degree from Yeshiva University in 2012. Professor Willner was a Postdoctoral Member of the Technical Staff at AT&T Bell Laboratories and a Member of the Technical Staff at Bellcore, now known as Telcordia. He is currently the Steven and Kathryn Sample Chaired Professor of Engineering in the Ming Hsieh Department of Electrical Engineering of the Viterbi School of Engineering at the University of Southern California. At USC, he is the Associate Director for the Center for Photonics Technology and was an Associate Director for Student Affairs for the National Science Foundation's Engineering Research Center in Multimedia. Professor Willner is a Member of the Defense Science Research Council, has served on many scientific advisory boards for small companies, and has advised several venture capital firms. Additionally, he was Founder and CTO of Phaethon Communications, a company acquired by Teraxion that created the ClearSpectrum® dispersion compensator product line which is presently deployed in many commercial 40-Gbit/s systems worldwide. Professor Willner has 975 publications, including one book, 24 U.S. patents, 19 keynotes/plenaries, 17 book chapters, 275 refereed journal papers, and 185 invited papers/presentations. His research is in optical communications, optical signal processing & networks, fiber optics, and optical technologies.

**Jie Yao**

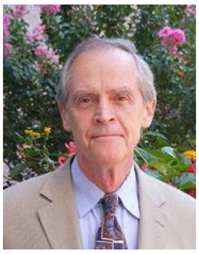


Professor Jie Yao joined the faculty of Berkeley Materials Science and Engineering in August, 2013. He earned his PhD in Applied Science and Technology (AS&T) at UC Berkeley in 2010. He subsequently did his postdoc research in the Department of Materials Science and Engineering at Stanford University. Professor Yao's research focuses on controlling the optical properties of matter through manipulation of structure and chemistry at the nano-scale. His research interests also include metamaterials design and applications, optical nano-cavities and light management for energy conversion.

**Xiaobo Yin**

Xiaobo Yin is an Assistant Professor of the Department of Mechanical Engineering and the Materials Science Engineering Program at the University of Colorado in Boulder. His current research focuses on the nanoscale science and technology, nanostructured materials and devices, metamaterials and nanophotonics, scalable and sustainable nano-manufacturing technology. Yin has authored more than 50 articles in peer-reviewed scientific journals and has given more than 10 invited presentations at international conferences and seminars. He received his Ph.D. in Electrical Engineering from Stanford University in 2008. Before joining the faculty of the College of Engineering and Applied Science, Yin was a post-doctoral researcher at Lawrence Berkeley National Laboratory and the senior scientist at the University of California-Berkeley.

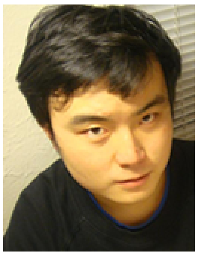
**John M. Zavada**



Dr. John Zavada received a B.A. degree in physics from Catholic University and a M.S. and Ph.D. in physics from New York University. After graduation, he joined the Army's Pitman-Dunn Laboratory in Philadelphia, PA, where he did research on light scattering from rough surfaces. In 1977, he moved to the Army's Picatinny Laboratory in Dover, NJ, where he performed research on the optical properties of semiconductor thin films. In 1984, he became a program manager in the Electronics Division of the Army Research Office in the Research Triangle, NC, where he managed extramural optoelectronics programs in photonic devices, advanced materials, and related technologies. He developed collaborations with many government agencies, including the Defense Advanced Research Projects Agency, and the High Energy Laser - Joint Technology Office. Dr. Zavada joined the National Science Foundation in August of 2010 where he currently holds the position of Program Director in the area of Electronics, Photonics, and Magnetic Devices. His program interests include emerging research areas in optoelectronics technologies, passive and active photonic devices, and integrated photonic device platforms. Silicon photonics, novel lasers, photo-detectors, heterogeneous integration, and devices for optical signal processing, sensing and communications are part of this program as well as device design, fabrication and integration at the micro- and nano-scale. His personal research has been on the optical properties of semiconductors, ion implantation, and effects of hydrogen and rare earth impurities in materials. He has authored more than 160 refereed publications and over 50 conference and seminar presentations. Dr. Zavada has held academic appointments at Drexel University, Duke University, North Carolina State University, and the Imperial

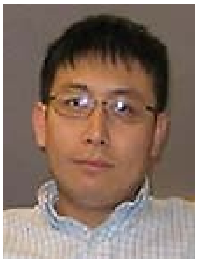
College of Science and Technology in London. He is a Fellow of the Optical Society of America and a recipient of the Army's Meritorious Civilian Service Award.

**Jinwei Zeng**



Jinwei Zeng is a Ph.D. student in Dr. Natalia M. Litchinitser's research group within the Department of Electrical Engineering at the State University of New York in Buffalo. His research fields revolve around Novel Photonics and Optics, including photonic crystal fiber, optic metamaterials, and singular optics. His role of research includes theory, modeling and experiment characterization. Mr. Zeng currently is a student member of SPIE and OSA.

**Shuang Zhang**



Shuang Zhang is a Professor in the school of Physics & Astronomy at University of Birmingham in the UK. He received B.S. in Physics from Jilin University, his M.S. in Physics from Northeastern University, and his Ph.D. in Electrical Engineering from the University of New Mexico.
From 2005 to 2006, he was a Postdoctoral Research Fellow at the University of Illinois at Urbana-Champaign, and from 2006 to 2010, he was first a Postdoctoral Research Fellow and later an Assistant Research Engineer at the University of California-Berkeley. In March 2010, he took the position of Reader in the School of Physics & Astronomy, University of Birmingham, and was promoted to professor in 2013.

Professor Zhang is the recipient of the International Union of Pure and Applied Physics Young Scientist Prize in Optics in 2010 for his research on optical metamaterials.

**Lei Zhou**

Professor Lei Zhou received his Ph.D. in Physics from Fudan University in China, in 1997. He then went to the Institute for Material Research at Tohoku University in Japan for postdoctoral research. From 2000 - 2004, he was a visiting scholar with Department of Physics at the Hong Kong University of Science and Technology. He joined the Physics Department of Fudan University in 2004 as a professor, and became a "Xi-De" Chair Professor in 2013. Starting from 1993, Professor Lei Zhou has been working in the fields of magnetism, meta-materials, photonic crystals and plasmonics, and he has published ~100 papers in scientific journals including Nature Materials, Nano Lett., Phys. Rev. Lett., Mater. Today. He is the co-author of a monograph (Springer) and 3 book chapters. By July 2013, his works have been cited more than 1400 times, with one paper receiving over 300 citations. He has successfully held two international conferences in Shanghai, and served as a program committee member or session chair in many top international conferences, and has been invited to give talks in many top international conferences. Professor Lei Zhou got the NSFC "Grant for Outstanding Young Scientist" in 2007 and was entitled the "Chang Jiang Scholars Program" Chair Professor in 2009.